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SOME LIMNOLOGICAL CHARACTERISTICS OF EIGHT LIMESTONE EXCAVATIONS IN SOUTH FLORIDA

Fish and Wildlife Service

U.S. Department of the Interior

Top photo by M. Hudy. A new limestone excavation underway near established excavations--a practice that substantially reduces the potential for mitigation of the common shorelines.

Bottom photo by R.W. Gregory. An older excavation, or rockpit, with well-established shoreline vegetation in a residential area.

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SOME LIMNOLOGICAL CHARACTERISTICS OF EIGHT LIMESTONE EXCAVATIONS IN SOUTH FLORIDA

by

Mark Hudy, Project Leader

and

Richard W. Gregory, Unit Leader
Florida Cooperative Fish and Wildlife Research Unit
117 Newins-Ziegler Hall
University of Florida
Gainesville, FL 32611

Contract No. 14-16-0009-80-059

Ronnie J. Haynes, Project Officer
U.S. Fish and Wildlife Service
Habitat Preservation, Technical Services Division
Atlanta, GA 30303

Robert J. Pennington, Project Inspector
U.S. Fish and Wildlife Service
Vero Beach, Field Office
Vero Beach, FL 32960

Performed for
Division of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

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PREFACE

Limestone mining in south Florida has affected several hundred square kilometers of land, primarily in Dade and Broward Counties. These operations typically exchange natural wetlands for large, deep excavation lakes that are of questionable value as fish and wildlife habitat, although very little background data on the ecology and fish and wildlife values of these excavations exist.

This study was implemented in 1981 to improve existing data and aid planners, landowners, and mine operators in their decision-making. The study has characterized some selected abiotic and biotic features of eight limestone excavations including water quality, macroinvertebrates, fish, and sediment contaminants. Also, an annotated bibliography of relevant literature is provided. A subsequent report, to be completed during 1984, will discuss wildlife use of limestone-excavation areas.

An original objective of this study was to evaluate the effectiveness of current mitigation recommendations, which include the post-mining creation of littoral areas and wetland habitat adjacent to excavations. It was not possible to accomplish this objective within the time frame of this study because no mitigated sites were available. Thus, this objective continues to be a high-priority research goal.

This study revealed that the biological productivity of the study lakes was limited. Species diversities were low, and growth and condition factors of largemouth bass were relatively poor compared with other south Florida waters. Water quality appeared to be adequate, and concentrations of heavy metals and pesticides in lake sediments were low. The data suggested that appropriate fish management practices could significantly improve fish populations in these lakes, and several management approaches to enhance biological productivity are presented. Additional information can be obtained by consulting references listed in the annotated bibliography.

The author accepts full responsibility for all statements, interpretations, citations of other investigations, and original data presented.

Any questions or comments about or requests for this publication should be directed to the following address.

Information Transfer Specialist
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
NASA/Slidell Computer Complex
1010 Gause Boulevard
Slidell, LA 70458

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CONVERSION FACTORS

METRIC (SI) UNITS OF MEASUREMENT TO U.S. CUSTOMARY UNITS

Metric (SI) units of measurement used in this report can be converted to U.S. customary units as follows:

Multiply	By	To Obtain
millimeters	0.03937	inches
centimeters	0.3937	inches
meters	3.28	feet
grams	0.0022	pounds
hectares	2.4710	acres
degrees celsius	1.8 (°C) + 32	degrees fahrenheit
milligrams/liter	1	parts/million
square meters	10.7639	square feet
square kilometers	0.3861	square miles
cubic meters	35.314	cubic feet
kilograms/hectare	--	pounds/acre

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INTRODUCTION

Miami Oolite limestone is the only significant construction material in south Florida and it is estimated that annual demand will approach 33 million tons by 1985 (Edgerton 1974). The mining of limestone in Florida and the application procedures for mining are regulated through several existing Federal and State laws (Federal: River and Harbor Act of 1899; The Fish and Wildlife Coordination Act of 1958; National Environmental Policy Act of 1969; Federal Water Pollution Control Act of 1972; Clean Water Act of 1977. State: Florida statutes Chapters 120, 161, 253, 258, 403) (U.S. Army Corps of Engineers 1977, 1981, 1982). The U.S. Army Corps of Engineers regulates the mining by authority of Section 404 of the Clean Water Act of 1977. Many local county and city ordinances and codes also regulate rock-mining (Broward County Code - Article II Excavation Regulations, Section 39-(912-921), Section 39-(1037-1039); Collier County Code - Ordinance No. 80-26, Sec. 1-18; Dade County Code - Section 39-13, Unusual Uses, Specific Criteria for Lake Excavations DERM 80-2) (U.S. Army Corps of Engineers 1977, 1981, 1982).

The mining of limestone, as described in detail by Edgerton (1974), typically exchanges natural and stressed wetlands for large, deep water-filled excavation lakes which are of questionable value as fish and wildlife habitat. These excavation lakes traditionally have been characterized as (1) steep sided with little or no littoral zone, (2) devoid of organic substrate, and (3) surrounded by a berm with no contiguous wetlands (Figure 1). In Dade County alone, there are over 120 km² of limestone excavations (based on 1978 aerial photographs), approximately 2% of the entire county. In addition, permit applications from 1978-80, as required by the U.S. Army Corps of Engineers, have been filed for mining another 13 km² (U.S. Army Corps of Engineers 1981).

To offset the loss of the high biological productivity of wetlands, and under existing regulations and agreements with the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service may recommend changes to proposed rock-mining plans to prevent or lessen adverse impacts to fish and wildlife (Council on Environmental Quality 1978; Stutzman 1980). Recommendations by the U.S. Fish and Wildlife Service are based on the principles and guidelines in the U.S. Fish and Wildlife Mitigation Policy (Federal Register 1981). Over the past several years mitigation recommendations by the U.S. Fish and Wildlife Service for proposed rock mines have included (1) the creation of littoral areas by sloping the sides of the excavations, (2) restrictions on removal of organic overburden, and (3)

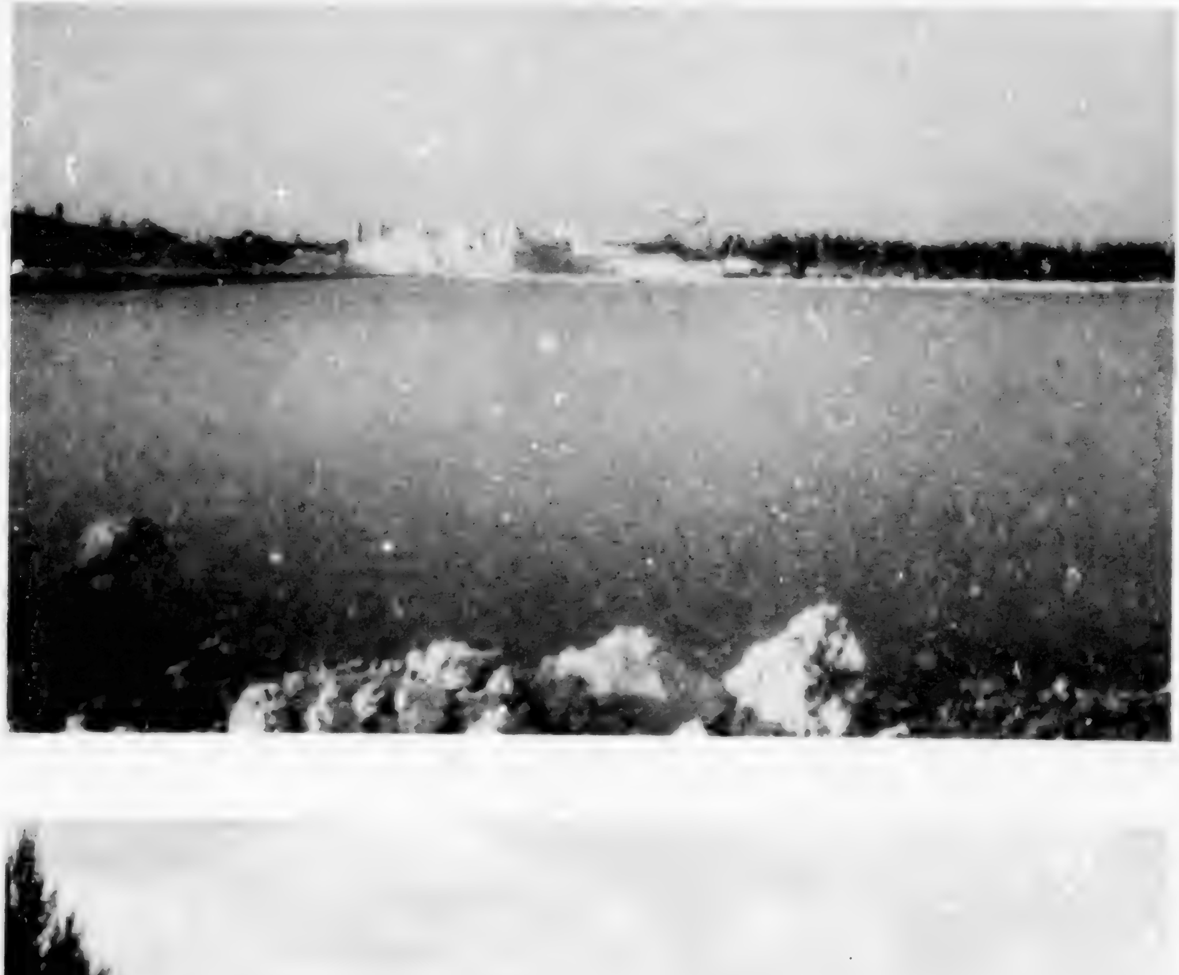
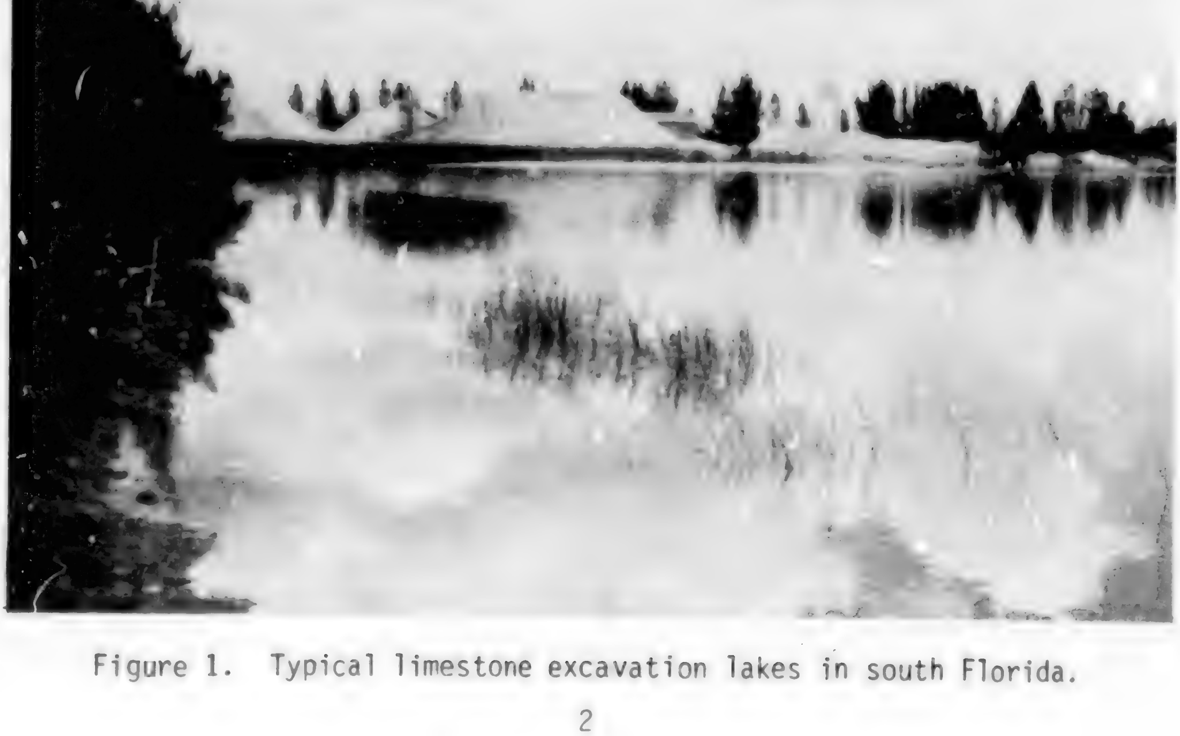

Figure 1. Typical limestone excavation lakes in south Florida.

creation of wetland habitat adjacent to excavations by removing overburden to the level of the water table. Little background data exists, however, about the ecology and fish and wildlife values of limestone excavations in south Florida and no data exists that evaluates the efficiency of mitigation recommendations.

One of the goals of this study was to assess the effectiveness of several specific reclamation/mitigation strategies for improving fish and wildlife values on lands disturbed by rock mining in south Florida. However, no excavation lakes could be located that would have undergone and completed mitigation within the time restraints of the study. Instead, this study has (1) characterized some abiotic and biotic aspects of water-filled limestone excavations; specifically limnology, macroinvertebrates, fisheries, and contaminants in lake sediments; (2) provided suggested options and guidance for the protection and enhancement of fish and wildlife values; and (3) provided an annotated bibliography of relevant literature. An additional investigation of wildlife use of the study area is scheduled for completion during 1984. The need to address the effectiveness of specific reclamation/mitigation strategies still remains and is proposed for future studies.

METHODS

SITE SELECTION, STUDY AREA

Ten limestone excavation lakes were selected through the use of topographical maps, aerial photos, and site visits. The selected sites are thought to best exemplify, within the scope of the study, the broad range of age, size, depth, and current use of rock-mining areas in south Florida. Mining was reactivated on two of the study lakes and sampling was discontinued 4 months into the study. The remaining eight lakes were 9 to 35 years old, 8 to 44 ha in surface area and had mean depths of 3.2 to 15.2 m (Table 1) (Figure 2).

The bottom of each lake was generally flat and was covered with very fine deposits of limerock up to 2.1 m in depth. Submergent vegetation varied among lakes ranging from almost nonexistent to complete coverage of the lake bottom (Table 1). The most common aquatic plants were *Chara* spp., *Najas* spp., *Potamogeton* spp., *Utricularia* spp., and *Hydrilla verticillata*. Perimeter vegetation around the excavations consisted primarily of exotic and pioneer type species (Appendix, Table A1).

Study lakes 1-4 were located in or near active mining areas where both public and private fishing, hunting, boating, and shooting activities were prohibited. The other lakes were, with some restrictions, available for recreational activities.

WATER QUALITY

Water quality characteristics were sampled every other month at each study site from May 1981 to May 1982. At each lake, water samples were collected 0.5 m below the surface at three random mid-lake locations. Reported values are means of the three samples. Water samples were collected in acid-washed polyethylene bottles and stored on ice for later analysis of total phosphorus, total nitrogen, total alkalinity, and total hardness (Hach Chemical Company 1975; American Public Health Association 1976). A Yellow Springs Instrument Co. Model 57 oxygen-temperature meter was used for oxygen and temperature measurements at depth intervals of 1 m. Conductivity was determined 1 m below the surface with a Yellow Springs Instrument Co. Model 33 conductivity meter. Water transparency was determined with a Secchi disk (20 cm in diameter) and pH was measured with an Orion Model 039410 pH meter.

Table 1. Location, age and morphometric features of eight limestone excavations in Dade County, Florida.

Lake	Location and use	Age (yr)	Surface area (ha)	Depth (m)		Lake bottom (% coverage by vegetation)
				mean	maximum	
1	T58S R39E S17 (mining)	11	44	15.2	18.3	5
2	T53S R39E S26 (mining)	11	41	12.3	17.7	5
3	T53S R39E S25 (mining)	18	37	12.9	14.6	5
4	T56S R40E S17 (mining)	25	15	6.7	8.3	10-20
5	T56S R40E S17 (agricultural)	9	8	8.7	11.3	70-80
6	T54S R40E S22 (recreational)	35	11	3.2	4.6	90-100
7	T54S R40E S23	28	31	3.7	5.5	90-100
8	T56S R40E S32 (agricultural	9	12	6.4	8.2	80-90

A measured volume of water, collected 0.5 m below the surface at 3 mid-lake locations, was filtered through a glass fiber 0.3 m filter for chlorophyll _a_ analysis. The filter was blotted dry, stored in desiccant and frozen until later analysis (American Public Health Association 1976).

MACROINVERTEBRATES

An Ekman dredge (152 x 152 mm) was used to collect macroinvertebrates at each lake. A total of 13-15 samples were taken at random locations in each lake; 4-5 each in December 1981, February and May 1982. Samples for each lake were pooled for analysis. Bottom samples were strained through a U.S. Standard No. 30 sieve. Remaining material was preserved with 70% ethyl alcohol until sorting and identification. Most macroinvertebrates were keyed to family.

BOTTOM SEDIMENTS

In a one-time survey bottom sediments from each study lake were collected during February 1982 with an Ekman dredge for analysis of percent

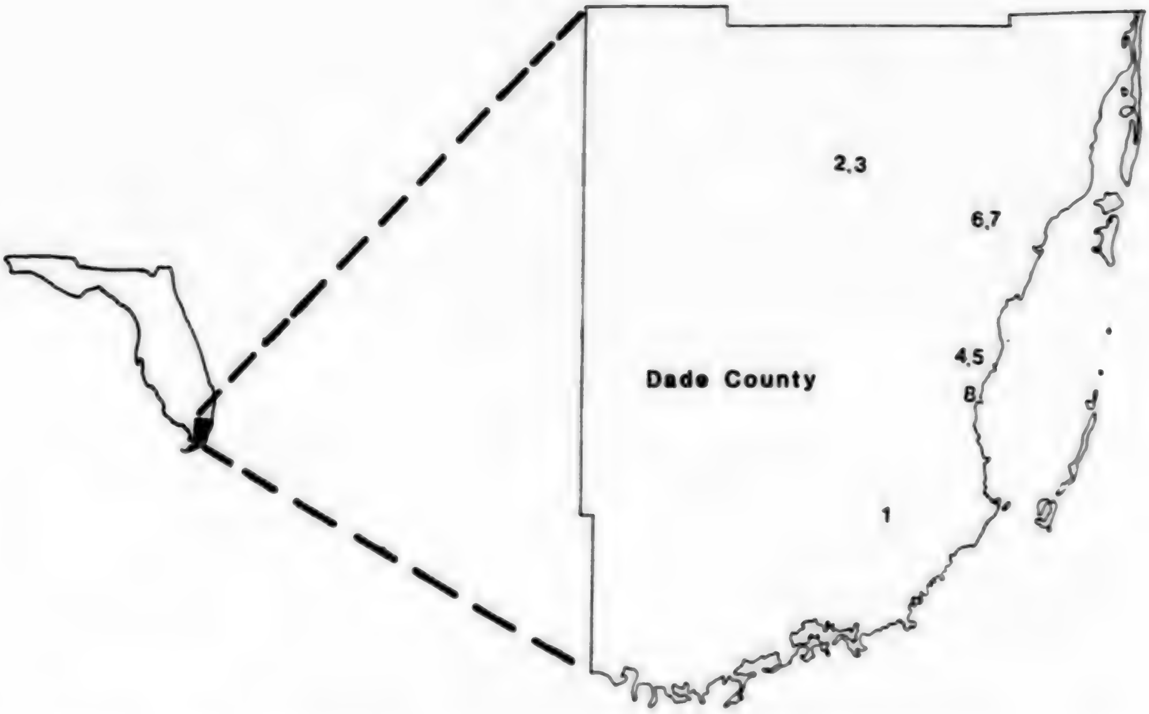

Figure 2. The location of the eight study lakes in Dade County, Florida. Numbers correspond to the descriptions in Table 1.

organic matter, trace elements, and pesticides. Organic content was determined by the Walkley-Black procedure (Allison 1965). Trace element concentrations were determined by particle induced x-ray emission (PIXE) (Johansson and Johansson 1976; Maenhaut et al. 1980) utilizing the Van de Graff accelerator at the Physics Department, University of Florida. Pesticide levels were determined by gas chromatography/mass spectrophotometer analysis using facilities at the Environmental Science Department, University of Florida.

FISHERIES

Floating and sinking monofilament experimental gill nets were used to collect fish from the study lakes in July 1981 and February 1982. Gill nets were either 91 x 1.8 m with four panels with bar mesh sizes of 2.5, 3.8, 5.1, and 6.4 cm or 38 x 2.4 m with five panels of bar mesh sizes 1.9, 2.5, 3.8, 5.1, and 6.4 cm. The two gill net catches were combined and a net hour was defined as 164 m^2 of net fished for 1 hour.

In February 1982, lakes with access for an electrofishing boat were electrofished at night using direct current. All fish regardless of size were netted. The number of minutes of electrofishing was recorded, and data was later converted to number of fish collected per hour.

In addition, underwater transects utilizing SCUBA gear were used during July 1981 to index fish populations (Northcote and Wilkie 1963; Werner et al. 1977). Two scuba divers simultaneously swam underwater transects, each 50 m in length, and separately identified and recorded the number of all fish greater than 150 mm in length. The two simultaneous counts were averaged for each transect and the mean of means was calculated from all transects for a given lake. Data was later converted to fish observed per 100 m transect.

All captured fish were weighed and measured and condition factor determined.

$$\text{condition factor} = \frac{\text{weight in grams} \times 10^5}{(\text{total length in millimeters})^3}$$

In February 1982, otoliths were taken from all captured largemouth bass (Micropterus salmoides) for age and growth determination (Taubert and Tranquilli 1982). Stomach contents of fish were routinely examined to identify important food items that may not have been collected in macroinvertebrate samples taken with an Ekman dredge.

RESULTS

WATER QUALITY

Little annual variation occurred in most water quality characteristics within a particular lake; however, there were some large differences in the means and ranges among lakes (Table 2). The range of water quality characteristics from this study was within the range of water quality reported in other south Florida studies on limestone excavations (Table 3).

In this study differences in water temperature and dissolved oxygen varied by lake, depth, and month sampled. Differences between surface and bottom water temperature were never greater than 3°C in lakes with mean depths less than 8 m. In lakes greater than 8 m in mean depth, differences in water temperature from surface to bottom were usually less than 5°C, but were as great as 8°-10° C in May through September (Appendix, Figures A1-A8). During the entire study the maximum observed water temperature was 33° C and the minimum 19° C (Table 2). The annual mean concentration of dissolved oxygen was 7.5-8.3 mg/l at the lake surfaces and 2.0-7.5 mg/l at the lake bottoms. Dissolved oxygen was infrequently below 5 mg/l except during July through September at water depths greater than 7 m (Appendix, Figures A1-A8).

There were annual variations within a lake in total alkalinity and total hardness, but variability was lake specific with no pattern common to all lakes (Appendix, Figures A9, A10). The range of means was 72-170 mg/l for alkalinity, and 82-230 mg/l for hardness (Table 2).

Annual variability within a lake was small for pH, conductivity, and transparency (Table 2). The mean pH ranged from 7.5 to 7.8 with the highest bimonthly reading 8.2 and the lowest 7.2. The range of means for conductivity was large, 221 to 1,058 µmhos with a high bimonthly reading of 1,150 µmhos and a low of 195 µmhos. Maximum transparency was 5.6 m and the minimum 1.4 m; means were 1.8 to 4.0 m (Appendix, Figures A1-A8).

Annual variations within a lake for total phosphorus, total nitrogen, and chlorophyll a were lake specific (Appendix, Figures A11-A13). Mean values for total phosphorus (7.1-12.3 mg/m³), total nitrogen (260-942 mg/m³), and chlorophyll a (0.5-4.2 mg/m³) varied greatly by lake; however all values were within the general trophic classification of oligotrophic or oligotrophic-mesotrophic lakes (Carlson 1977).

Table 2. Mean and range of selected water quality parameters of eight limestone excavations in Dade County, Florida. Data collected bimonthly May 1981 - May 1982.

Lake[1]	D.O. (mg/l)		Temperature (°C)		Total Phosphorus (mg/m^3)	Total Nitrogen (mg/m^3)	Chlorophyll a[2] (mg/m^3)	Alkalinity (mg/l)	Hardness (mg/l)	pH	Conductivity (μmhos)	Secchi disk (m)
	Surface	Bottom	Surface	Bottom								
1	7.6 (6.8-8.7)	6.0 (3.5-7.8)	26 (21-30)	24 (20-27)	7.4 (4-12)	260 (200-350)	0.5 (0.3-0.7)	125 (111-141)	230 (206-252)	7.6 (7.3-7.8)	1,058 (970-1,150)	2.7 (1.9-3.8)
2	7.5 (6.5-8.9)	2.0 (0.0-6.2)	27 (21-31)	21 (19-25)	7.1 (4-10)	942 (780-1,070)	2.4 (1.7-3.3)	170 (151-181)	188 (170-203)	7.7 (7.4-8.2)	477 (410-510)	2.2 (1.8-2.4)
3	7.5 (7.0-7.9)	4.1 (0.2-7.0)	26 (20-31)	23 (19-25)	9.1 (5-14)	727 (690-770)	1.2 (0.6-2.4)	129 (113-148)	147 (132-161)	7.6 (7.4-8.2)	412 (400-435)	1.8 (1.4-2.8)
4	7.6 (5.2-8.1)	5.6 (0.1-7.3)	27 (21-31)	26 (20-30)	10.9 (6-23)	586 (540-720)	3.0 (1.4-4.4)	112 (92-130)	161 (194-228)	7.6 (7.2-8.1)	1,004 (850-1,100)	3.4 (1.8-5.6)
5	7.8 (6.5-9.5)	5.5 (0.2-7.0)	27 (21-32)	25 (20-30)	10.5 (7-15)	379 (290-440)	1.8 (0.8-2.7)	117 (106-127)	189 (170-202)	7.5 (7.3-7.8)	824 (710-920)	3.7 (2.3-5.2)
6	8.3 (7.1-9.4)	7.5 (4.2-9.2)	27 (21-33)	27 (20-32)	10.0 (7-15)	761 (690-830)	1.2 (0.8-2.2)	80 (72-89)	87 (77-104)	7.7 (7.5-8.1)	221 (195-260)	4.0 (3.6-b)
7	7.7 (7.0-8.7)	7.1 (6.0-8.5)	27 (21-33)	27 (21-33)	12.3 (6-17)	793 (770-810)	2.7 (1.5-3.9)	72 (58-81)	82 (65-96)	7.8 (7.4-8.1)	260 (250-290)	3.3 (2.1-b)
8	8.0 (6.0-10.3)	5.7 (0.5-8.0)	26 (20-31)	26 (19-30)	11.8 (8-18)	342 (300-450)	4.2 (1.7-5.7)	88 (49-113)	122 (85-157)	7.7 (7.2-8.2)	432 (395-480)	3.3 (1.9-4.8)

[1] = See table 1 for lake descriptions.
[2] = No phaeothytin correction made.
b = Lake bottom.

Table 3. Summary of selected data from water quality studies on limestone excavations in south Florida.

Study	Number of lakes	Sampling frequency (per year)	pH	Conductivity (μmhos)	Alkalinity (mg/l)	Total nitrogen (mg/m^3)	Total phosphorus (mg/m^3)	Chlorophyll a (mg/m^3)
Pope (1967)	2	26	7.8-8.8	NA[a]	32-205	NA	NA	NA
Pope (unpublished, 1976)	124	1	7.0-8.9	105-10,000	54-265	NA	NA	0-65
Rhoads (1969)	1	26	NA	NA	45-109	NA	NA	NA
Beaven and McPherson (1978)	3	1	7.8	535	125	530	30	NA
Environmental Science and Engineering (1979)	4	4-40	6.1-8.4	41-1,700	NA	490-4,010	50-7,980	1.3-44.4
Weinberg et al (1980)	1	10	7.0-8.2	282-457	138-220	610-650	NA	NA
Canfield (1981)	1	3	8.6-9.3	160-173	50-88	566-608	10-28	0.8-9.5
U.S. Army Corp of Engineers (1982)	21	1	NA	270-> 8,000	NA	140-4,400	< 5-2,180	NA
This study	8	7	7.2-8.2	195-1,150	49-181	200-1,070	4-23	0.3-5.7
Overall	165	1-40	6.1-8.9	41-10,000	32-265	140-4,400	4-7,980	0-65

[a] NA = Not applicable.

No significant correlation among the mean depth, age, or surface area of each lake and total phosphorus, total nitrogen, or chlorophyll *a* was found (Spearman's rank correlation $P \leq 0.05$ (Ostle and Mensing 1975). Mean depth was positively correlated ($P \leq 0.05$) with total alkalinity and total hardness.

BOTTOM SEDIMENTS

Bottom sediments, regardless of excavation age, contained a low percentage of organic matter, 0.34% to 3.70% (Table 4). No gross contamination by heavy metals or pesticides was found in any lake. The major elements found in the sediments were calcium, potassium, iron, manganese, strontium, zirconium, zinc, lead, copper, arsenic, bromine, and chromium (Table 4). Concentrations of most trace elements were within the range reported for canals, marshes, and limestone excavations in south Florida (Table 5). Lead and zinc concentrations were highest in the residential (Lake 7) and recreational (Lake 6) lakes, study areas that were surrounded by roads. The highest concentrations of lead (89.5 mg/g) and zinc (47.5 mg/g) were much less than the maximum levels found in other south Florida sediments (Table 5). No pesticides were detected, in lake sediments within the detection limits of the analyses, even though some of the pesticides we analyzed for have been found in other south Florida sediment studies (Table 6).

MACROINVERTEBRATES

There were significant differences among lakes in the number of macroinvertebrates per square meter (Duncan's multiple range test, $N = 103$, $P \leq 0.05$). The mean number ranged from 218 to 2,704/m2 (Table 7). Dipterans (Chironomidae, Chaoboridae and Ceratopogonidae) were the most abundant, followed by Trichoptera (Polycentropodae), Ephemeroptera (Caenidae), and Odonata (Libellulidae, Coenagrionidae). Leeches (Hirudinea), gastropods (Planorbidae, Pleuroceridae), and water mites (Acarina) were only collected occasionally. The age of each lake was not correlated with the density of macroinvertebrates or the number of families present. Mean depth of the study lakes was negatively correlated with the number of macroinvertebrates/m^2 and the number of families of macroinvertebrates found in each lake (Spearman's rank correlation, $P \leq 0.05$).

The prawn (*Palaemonetes paludosus*) and crayfish (*Procambarus alleni*) were found in several largemouth bass stomachs collected from lakes 6 and 7 although none appeared in Ekman dredge samples.

FISHERIES

None of the collection techniques employed captured enough fish to obtain a usable population estimate by mark-recapture methodology. Catch per unit effort (CPUE) was low regardless of sampling method (Table 8). Electrofishing CPUE ranged from 13 to 361 fish/hour, gill netting CPUE was

Table 4. Summary of the % organic matter and major elements found in bottom sediments of eight limestone excavations in Dade County, Florida; concentration of elements in mg/g.

Lake[a]	% organic matter	Major elements											
		As	Br	Ca	Cr	Cu	Fe	Pb	Mn	K	Sr	Zn	Zr
1	0.68	7.7	14.8	476,600	8.9	3.8	4,055	13.8	32.3	20,370	1,913	5.6	8.3
2	0.54	2.4	4.2	345,000	7.4	2.7	3,319	12.6	48.1	18,012	868	4.7	11.7
3	0.34	2.5	2.8	398,756	0.9	3.9	1,906	7.7	33.8	15,912	791	3.0	6.5
4	2.90	5.6	46.4	350,510	4.9	10.5	1,948	14.5	28.6	13,054	2,978	19.7	29.6
5	1.00	3.4	10.4	303,900	3.7	2.7	2,466	13.6	15.4	23,333	3,334	4.4	38.1
6	0.88	0.6	94.5	347,005	2.3	6.4	4,402	84.5	20.8	13,352	4,139	47.5	12.2
7	3.70	2.8	6.9	305,600	2.9	3.4	2,521	89.5	41.1	12,180	2,288	14.8	9.0
8	1.40	2.6	24.0	371,580	12.1	6.8	3,118	34.6	54.9	17,760	3,451	12.9	13.9

[a] See Table 1 for lake description.

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Table 5. Summary of selected south Florida studies analyzing heavy metals and other elements in bottom sediments; all values in μg/g.

	Sample types (study)				
Element	Rock mines (Present (study)	Rock mines (Beaven and McPherson 1978)	Canals, marsh (Waller 1981)	Canals (Russo 1974)	Canals (Miller 1978)
Aluminum	5	NR	NR	8-3,190	NR
Arsenic	0.6-7.7	ND	0-40	NR	1-6
Bromine	2.8-94.5	NR	NR	NR	NR
Cadmium	5	10	10	NR	NR
Calcium	303,900-476,600	NR	NR	NR	NR
Chromium	0.9-12.1	10	10-70	11-180	NR
Cobalt	5	30	NR	NR	NR
Copper	2.7-10.5	20	10-12	24-81	12-45
Iron	1,906-4,402	470	1,500-17,000	760-15,800	1,800-4,500
Lead	7.7-89.5	500	10-60	44-1,110	65-750
Manganese	15.4-54.9	20	20-260	0-86	NR
Mercury	NR	0.2	0-0.3	0-1.4	NR
Molybedum	5	10	NR	NR	NR
Nickel	5	10	10-30	NR	NR
Strontium	791-4,139	NR	NR	NR	330-1,600
Zinc	3.0-47.5	140	10-90	90-360	NR
Zirconium	6.5-38.1	NR	NR	NR	NR

NR = Not reported or analyzed in study.
ND = Not detected.

Table 6. Summary of selected south Florida studies analyzing pesticides in bottom sediments; all values in μg/kg.

	Sample types (study)					
Pesticide	Rock mines (Present study)	Rock mines (Beaven and McPherson 1978)	Canals (Miller 1978)	Canals, marsh (Waller 1981)	Canals (Sonntag 1980)	Marsh (McPherson 1973)
Aldrin	3.7	ND	ND	ND	ND-2	ND
α chlordane	2.5	ND	ND-120[a]	ND-5[a]	ND-370[a]	ND-50[a]
γ chlordane	0.3	ND	NR	NR	NR	NR
DDD	NR	ND	ND-22	N.D.-0.2	ND-100	ND-870
DDE	3.0	16	1.5-49	0.5-6.9	ND-130	ND-740
DDT	32	0.6	ND-110	ND	ND-160	ND-12
Diazinon	NR	ND	ND	NR	ND-0.7	NR
Dieldrin	2.0	22	ND-3.2	ND	NR	ND-17
Endrin	0.5	ND	ND	ND	ND	ND
Ethion	NR	ND	ND	NR	ND-55	NR
Heptachlor	2.8	ND	ND	ND	ND	ND
Lindane	NR	NR	ND	ND	ND	ND
Malathion	22	ND	ND	NR	ND	NR
Mirex	1.5	NR	NR	ND	NR	NR
PCB	NR	53	70-130	ND	ND-700	ND-1900
Parathion	23	ND	ND	NR	ND	NR
Silvex	7	NR	NR	NR	ND-310	ND-78
Toxaphene	NR	ND	ND	ND	ND	NR
Trithion	NR	ND	ND	NR	ND-29	NR
2,4-D	NR	ND	ND	NR	ND	ND-0.2
2, 4, 5-T	NR	ND	ND	NR	ND	ND

[a] Only reported as chlordane.

NR = Pesticide not reported or analyzed for in study.
ND = Pesticide not detected, detection limits not given.

Table 7. Percent composition of each taxon of macroinvertebrates collected from eight limestone excavations in Dade County, Florida. Samples collected by Ekman dredge in December 1981 and February and May 1982. When the same letter (w,x,y,z) appears under the numbers of macroinvertebrates per square meter (in parenthesis, in box heading), the numbers are not significantly different according to Duncan's multiple range test ($P \geq 0.05$, $N = 103$).

	Lake (See Table 1 for description)							
	1	2	3	4	5	6	7	8
Mean/m²	(218) w	(869) w,x	(460) w	(1,785) x,y	(4,382) z	(1,591) x	(2,704) y	(1,858) x,y
TAXON								
Insecta								
Diptera								
Chironomidae	93	27	54	70	30	73	50	63
Chaoboridae		71	35	18	69		16	28
Ceratopogonidae	5	T	10	5		20		2
Ephemeroptera								
Caenidae				T[a]		2		T
Odonata								
Libellulidae						T	T	T
Coenagrionidae						T	T	T
Trichoptera								
Polycentropodae	T			T		3	8	T
Crustacea								
Amphipoda								
Talitridae				5		T	21	5
Gastropoda								
Basommatophora								
Planorbidae	T					T	3	
Mesogastropoda								
Pleuroceridae				T				
Arachnida								
Acarina						T		T
Hirudinea		T	T		T	T		T

[a] T = Trace amounts, less than 1%.

Table 8. Effort and catch per unit effort of all fish species by electrofishing, gill netting and SCUBA transects in eight limestone excavations in Dade County, Florida.

Lake[a]	Electrofishing	Gill netting[b]	SCUBA[c]
	Total hours/fish per hour (largemouth bass/hour)	Total hours/fish per net hour (largemouth bass/net hour)	Number transects/fish per 100 m (largemouth bass/100 m)
1	NS[d]	13.9/.29 (.29)	3/0.0
2	2.8/20(7)	38.9/.26 (.25)	NS
3	2.6/63(7)	34.5/.09 (.03)	NS
4	2.3/13(1)	76.9/.14 (.01)	3/16 (1.3)
5	NS	73.9/.43 (.27)	3/5.6 (1.5)
6	1.8/110 (12)	42.8/.65 (.46)	3/11.7 (5.0)
7	1.8/39 (19)	13.9/1.29 (1.22)	NS
8	1.6/261 (9)	78.2/.87 (.52)	3/19.3 (5.6)
Overall/mean	12.9/73	373/.46	15/10.5

[a] See Table 1 for lake descriptions.
[b] Net hour equals 165 m^2 of net fished one hour.
[c] Only fish greater than 150 mm counted.
[d] NS = not sampled.

0.01 to 1.22 fish/net-hour, and scuba transects had CPUE of 0.0 to 19.3 fish/100 m of shoreline. Highest CPUE was in the shallow, weedy, or shoreline areas of most lakes. Few fish were observed or collected more than 10 meters from the lake edges except in the lakes shallow enough to have submergent vegetation throughout the majority of the lake bottom (Lakes 5-8).

Species composition of fish collected was similar to that found in surrounding canals and wetlands (Table 9) (Kushlan and Lodge 1974). Largemouth bass, redear sunfish (Lepomis microlophus), bluegill (Lepomis macrochirus), and mosquitofish (Gambusia affinis) were common to all lakes.

There were significant differences among lakes in the mean length, weight, and condition factor of 1-year-old largemouth bass (Table 10) (Duncan's multiple range test, $N = 91$, $P \leq 0.05$). Mean length varied from 143 to 206 mm, weight 31 to 102 g, and condition factor 0.99 to 1.20. No 1-year-old largemouth bass were collected in lakes 1 and 7. We also found significant differences among lakes in the mean length, weight, and condition factor of 2-year-old largemouth bass (Table 11) (Duncan's multiple range test, $N = 54$, $P \leq 0.05$). Mean lengths were 220-301 mm, weights 113-331 g, and condition factors 1.03-1.20. No 2-year-old largemouth bass were collected from lakes 1 and 4. No significant correlation (Spearman's rank correlation, $P \geq 0.05$) among lakes in the growth or condition factor of 1- and 2-year-old largemouth bass and mean depth, age, or surface area was found. Few largemouth bass 3 or more years old were collected. Only 12% of all the largemouth bass collected were longer than 300 mm, and less than 1% exceeded 350 mm (Figure 3).

The sample sizes of other fish species were not large enough to evaluate age, growth or length and weight frequencies. The mean lengths and range of lengths of selected species is summarized by lake in Table 12. Redear sunfish from all lakes were 43 to 276 mm long; lake means were 102 to 221 mm. Bluegill lengths averaged 57 to 91 mm, the maximum length was 260 mm and the minimum 25 mm. Warmouth (Lepomis gulosus), spotted sunfish (Lepomis punctatus), walking catfish (Clarias batrachus), Florida gar (Lepisosteus platyrhincus), and spotted tilapia (Tilapia mariae) were collected infrequently (Table 12).

Table 9. Occurrence of fish species collected during this study by experimental gill nets and electrofishing in eight limestone excavations in Dade County, Florida.

Species	Lake[a]							
	1	2	3	4	5	6	7	8
Largemouth bass	✓	✓	✓	✓	✓	✓	✓	✓
Redear sunfish	✓	✓	✓	✓	✓	✓	✓	✓
Bluegill	✓	✓	✓	✓	✓	✓	✓	✓
Warmouth		✓	✓	✓		✓	✓	
Spotted sunfish				✓		✓	✓	
Mosquitofish	✓	✓	✓	✓	✓	✓	✓	✓
Sailfin molly		✓	✓	✓				
Variable platyfish				✓				
Brook silverside		✓	✓	✓				
Black acara								✓
Spotted tilapia						✓		✓
Florida gar		✓	✓	✓			✓	
American eel			✓					
Walking catfish				✓	✓		✓	✓
Threadfin shad				✓				
Striped mullet				✓				
Brown bullhead			✓					
Golden shiner				✓				

[a] See Table 1 for description.

Table 10. Mean length, weight, and condition factor of one-year-old largemouth bass collected February 1982 in eight limestone excavations in Dade County, Florida. Means followed by a common letter in the same column are not significantly different according to Duncan's multiple range test ($P \geq 0.05$, $N = 91$).

	One-year-old largemouth bass		
Lake[a]	Mean length (mm)	Mean weight (g)	Mean condition factor
1	NA[b]	NA	NA
2	163 x,y	46 x,y	.99 x
3	143 x	31 x	1.02 x,y
4	206 z	107 z	1.20 z
5	NA	NA	NA
6	153 x	61 y	1.16 z
7	159 x,y	48 x,y	1.08 y
8	195 y,z	102 z	1.16 z

[a] See Table 1 for lake description.
[b] NA = Not applicable, not enough collected.

Table 11. Mean length, weight, and condition factor of two-year-old largemouth bass collected February 1982 in eight limestone excavations in Dade County, Florida. Means followed by a common letter in the same column are not significantly different, Duncan's multiple range test ($P \geq 0.05$, N = 54).

Lake[a]	Two-year-old largemouth bass		
	Mean length (mm)	Mean weight (g)	Mean condition factor
1	NA[b]	NA	NA
2	253 y	169 x,y	1.03 x
3	220 x	113 x	1.02 x
4	NA	NA	NA
5	239 x,y	175 x,y	1.20 z
6	301 z	331 z	1.18 z
7	239 x,y	148 x,y	1.08 x,y
8	256 y	197 y	1.15 y,z

[a] See Table 1 for lake description.
[b] NA = Not applicable, not enough collected.

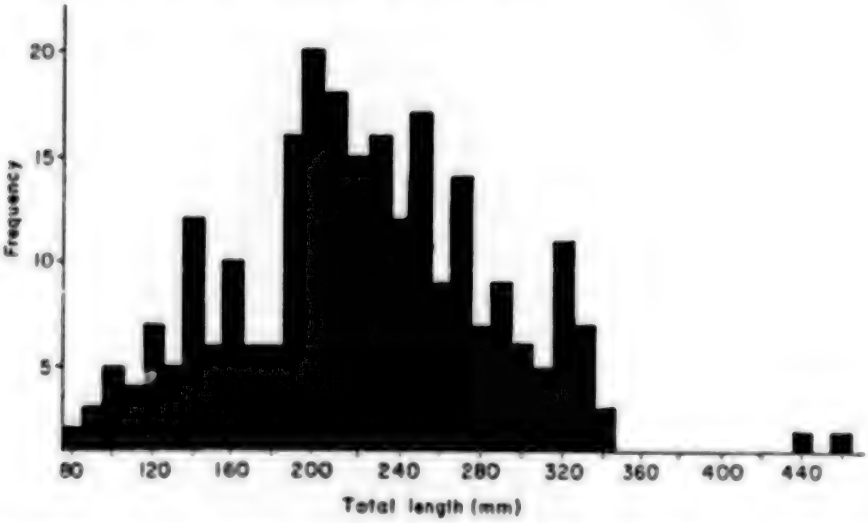

Figure 3. Length frequency of largemouth bass collected in eight limestone excavation lakes, Dade County, Florida. Fish collected by electrofishing, gill netting, and angling; July 1981 - February 1982; N = 224.

Table 12. Mean length (mm) and range of selected fish species collected by experimental gill nets and electrofishing in eight limestone excavation lakes in Dade County, Florida. Sample size in parenthesis.

Lake[a]	Largemouth bass (*M. salmoides*)	Redear sunfish (*L. microlophus*)	Bluegill (*L. macrochirus*)	Warmouth (*L. gulosus*)	Spotted sunfish (*L. punctatus*)	Walking catfish (*C. batrachus*)	Florida gar (*L. platyrhincus*)	Spotted tilapia (*T. mariae*)
1	239 (7) 231-258	NA[b]	NA	NA	NA	NA	NA	NA
2	220 (30) 123-440	NA	76 (10) 57-156	NA	NA	NA	NA	NA
3	164 (23) 108-250	127 (29) 78-185	91 (60) 25-193	NA	NA	NA	NA	NA
4	212 (15) 196-282	162 (5) 43-276	NA	100 (6) 48-144	NA	168 (17) 107-290	535 (18) 484-619	NA
5	278 (18) 155-334	197 (14) 138-259	NA	NA	NA	NA	NA	107 (8) 45-179
6	245 (41) 85-473	113 (42) 49-195	68 (136) 35-163	53 (11) 40-82	59 (5) 57-62	NA	NA	NA
7	216 (52) 119-283	NA	77 (24) 31-173	NA	141 (5) 124-157	NA	NA	NA
8	233 (55) 167-336	221 (6) 181-265	57 (396) 31-260	NA	NA	372 (6) 359-385	NA	102 (5) 30-211

[a] See Table 1 for lake descriptions.
[b] NA = Less than 5 collected.

DISCUSSION

WATER QUALITY

A wide range of water quality characteristics has been found in limestone excavation lakes in south Florida (Table 3). While the range of most water quality characteristics is well within the range of tolerance for most fish, certain conditions such as low nutrient levels may limit the productivity of limestone excavations. In many quarry lakes, levels of phosphorus, nitrogen, and chlorophyll a are lower than found in other Florida waters (Miller 1975; Environmental Protection Agency 1978; Canfield 1981). Based on these low phosphorus and nitrogen levels, most limestone excavations can be classified as relatively unproductive or oligotrophic-mesotrophic systems (Carlson 1977; Canfield 1981). However, in some south Florida urban limestone lakes, high phosphorus and nitrogen levels exist that are indicative of eutrophic conditions (Jackson and Maurrasse 1976). Aquatic weed and water quality related problems such as odors and fish kills occur more frequently under these eutrophic conditions (Jackson and Maurrasse 1976).

The lake-specific effects of any special reclamation/mitigation approaches on water quality cannot be demonstrated because no pre- and post mitigation studies have been conducted to evaluate various mitigation strategies. The wide range of water quality existing in limestone excavations also makes generalizations about the effects of mitigation highly speculative. Generally mitigation measures such as (1) removal of berms, (2) sloping to create littoral areas, and (3) return of some portion of the organic overburden to littoral areas should be expected to increase the amounts of allochthonous matter and nutrients entering excavation lakes. The increase in allochthonous matter and nutrients should help increase the productivity of most lakes. However, in urban areas that produce nutrient rich runoff, the removal of the berm may greatly accelerate eutrophication as the natural filtering capacity of littoral and wetland areas may be exceeded (Steward 1976; Sloey et al. 1978; Prentki et al. 1978).

Mitigation measures as stated above would probably have little effect on temperature, alkalinity, pH or hardness. Dissolved oxygen levels would rarely be a problem, with or without mitigation, on a whole lake basis. However, dramatic increases in productivity and resulting eutrophication could result in a depletion of dissolved oxygen in the hypolimnion of the deeper excavation lakes.

BOTTOM SEDIMENTS

The removal of organic overburden from mining areas and the building of a berm around the lake severely limit the amount of organic matter in limestone excavations. In natural lakes in Florida, the percentage of organic matter in bottom sediments was rarely below 30% and ranged from 5% to 83% (Flannery et al. 1982). The maximum percentage of organic matter in bottom sediments in this study was only 3.7%. While berms, in part, help limit organic matter and nutrients from outside sources they may help prevent contamination of the excavation lake and aquifer. To what extent berms, bottom sediments, wetland and littoral areas, and aquifer materials prevent contaminants from infiltrating an aquifer is not understood and needs additional study. Miller (1978) found that south Florida canal bottom sediments filtered out some of the coliform bacteria, pesticides, metals, and other suspended materials from canal water infiltrating the Biscayne aquifer. No evidence of gross contamination by heavy metals or pesticides in the bottom sediments was found in the lakes sampled during this study. Whether or not the berms contributed to these results could not be determined, especially since study sites were not in heavily polluted areas. While removal of berms in remote areas is not likely to lead to an increase in contaminants infiltrating an aquifer, the effects of berm removal in urbanized, polluted areas is not known and should be considered in planning.

MACROINVERTEBRATES

The number of macroinvertebrates was generally within the densities reported for freshwater Florida habitats (Wegener et al. 1974; Waller 1976); however, diversity was low in this study and dominated by the Chironomidae and Chaoboridae. Important fish food invertebrates of other Florida waters (Mclane 1948; Huish 1949; Wegener et al. 1974), such as scuds, freshwater shrimp, crayfish, dragonflies, damselflies, mayflies, and other littoral species were absent or rarely found in dredge samples or in largemouth bass stomachs examined during the study. The lack of littoral areas, small amounts of submergent and emergent aquatic vegetation, and great mean depths of some limestone excavation lakes, likely limit diversity of macroinvertebrates (Moyer and Williams 1982). The small percentage of organic matter in lake sediments may also be limiting the densities of certain functional groups of aquatic insects such as the collectors and shredders which feed on fine and coarse organic matter (Merritt and Cummins 1978). Specific mitigation recommendations that increase littoral areas, aquatic vegetation, and organic matter in excavation lakes should increase the diversity and density of important fish food items.

FISHERIES

The low CPUE, regardless of method, in both fished and unfished lakes, suggest low densities and standing crops of fishes. Lakes with nutrient levels similar to those found in this study can be expected to have low standing crops of fishes, even with excellent fish habitat (Oglesby 1977; Kautz 1980; Hanson and Leggett 1982).

Traditional fisheries techniques used for standing crop and population estimates in Florida could not be used in this study because (1) block nets, drop traps (Kushlan 1974), and Wegener rings (Wegener et al. 1973) are for sampling relatively shallow water; (2) too few fish were collected by the methods we employed for mark-recapture population estimates; and (3) total eradication with rotenone was too expensive.

Standing crop estimates have been done on very small, shallow south Florida limestone excavations (Florida Game and Fresh Water Fish Commission 1975, 1978, 1979, 1980). Standing crops of fishes were 29-231 pounds per acre, which is within the range reported for sawgrass, slough, and wet prairie communities in Florida, but is below that of south Florida lakes and canals (Dineen 1964a, 1965; Florida Game and Fresh Water Fish Commission 1968, 1980). Standing crop estimates on small, shallow excavations are not comparable to the large, deep excavations studied. The latter have small amounts of shallow vegetated habitat that may limit fish productivity. Marsh, littoral, and other vegetated areas are important fish rearing and feeding areas. In the Everglades, canals with adjacent marsh had more fish and more pounds of fish than canals with a berm and no marsh (Dineen 1965). In Lake Tohopekaliga, shallow, vegetated habitats had considerably more value per acre than the limnetic areas of the lake (Wegener and Holcomb 1972; Wegener et al. 1973).

Limestone excavations that have little shallow vegetated habitat probably have even lower standing crops of fishes than the small borrow pits studied in south Florida or other oligotrophic lakes in Florida (Kautz 1980). The absence of littoral areas, which are important fish food habitats (Moyer and Williams 1982), may also explain the poorer growth of largemouth bass in excavation lakes relative to other south Florida environments.

In the Everglades, largemouth bass reach lengths of 228-254 mm in 1 year and 343-419 mm in 2 years (Dineen 1974). In a fertilized excavation lake, stocked with forage fish, growth was also better than found in this study (Clugston 1963). One-year-old largemouth bass were 275-311 mm long, 351-459 g in weight, and had condition factors of 1.43-1.65 (Clugston 1963). The absence of littoral areas not only may limit growth, but it also may limit spawning success.

The initial composition of fish in most limestone excavations is primarily dependent on (1) what fish have been stocked by individuals, and (2) movements of fishes from adjacent canals and wetlands during high water conditions. Most of the fish collected, with the exception of American eel (Anguilla rostrata) and striped mullet (Mugil cephalus), are capable of reproducing in limestone excavations on a limited basis. Mitigation measures that create additional shallow, vegetated habitat would enhance the reproductive success of most fish species by providing additional fish spawning and rearing habitat.

NEED FOR ENHANCEMENT OF FISH HABITAT

Original project objectives called for the evaluation of specific mitigation strategies; however, we were unable to locate any excavations where mitigation techniques had yet been implemented. Consequently, we cannot provide specific data which demonstrates that mitigation can enhance fish and wildlife use of rock-mined areas in south Florida. General impressions of low productivity and poor biological diversity in limestone excavations were substantiated by this study and clearly document the opportunity to enhance fish productivity and recreational values in rock-mined areas. Examples of various habitat enhancement techniques are available in the literature (Swanson 1979; Mason 1982).

Before any site-specific mitigation recommendations can be made, the potential uses and local priorities of the mining area should be determined and considered in the reclamation planning process. Mitigation recommendations that provide for residential areas or the prevention of aquifer contamination may differ significantly from those aimed at enhancement of fish and wildlife values. Regardless of the proposed primary post-mining land use, we believe that fish and wildlife values can be economically integrated into reclamation plans by recognizing the habitat needs of desirable species and providing for these needs accordingly. Regardless of whether or not the improvement of fish and wildlife values is the primary or secondary goal, we believe that biological productivity of many limestone lakes can be improved by: (1) creating shallow, vegetated littoral areas, (2) replacing organic matter in lake sediments, and (3) creating bermless lakes with contiguous wetlands. Mitigation aimed at providing these recommendations appears to be justified and should be continued, but the types and amounts of mitigation that will best enhance fish and wildlife values require further study.

Urban expansion, mining economics, aquifer contamination, and community priorities and needs may dictate that many rock-mining areas will not undergo mitigation solely for fish and wildlife. Some trade-offs will undoubtedly occur that may discourage enhancement of fish and wildlife values.

SUMMARY OF CHEMICAL AND BIOTIC CHARACTERISTICS OF STUDY LAKES

1. A wide range of water quality exists among limestone excavation lakes in south Florida; however, there is little annual variability within a lake.

2. Although the water quality of most limestone excavation lakes is suitable for fish and macroinvertebrates, the low amounts of nutrients in these oligotrophic lakes, in part, limit productivity.

3. Concentrations of heavy metals and pesticides in lake sediments from this study were low except for strontium and did not exceed background data from south Florida.

4. The bottom sediments of study lakes had a low percentage of organic matter relative to natural lake and wetland systems in Florida.

5. Macroinvertebrate densities were within the range reported for south Florida, but species composition was different and diversity was low. Littoral and important fish food species were rarely collected.

6. Regardless of age, macroinvertebrate density and diversity was greater in the shallower lakes.

7. Catch per unit effort of all fish by electrofishing, gill netting, and underwater transects in both fished and unfished lakes indicated low densities and low standing crops of fish.

8. Growth and condition factor of largemouth bass was poor relative to other south Florida waters.

RESEARCH AND INFORMATION NEEDS

Additional research is needed to mitigate for both community and fish and wildlife needs. There is an immediate need to develop demonstration projects which can address these issues. Some specific areas where additional aquatic research is needed include:

(1) Effectiveness of berms, bottom sediments, and aquifer materials in preventing surface runoff contaminants from infiltrating the aquifer.

(2) Current public demand and projected use of rock-mining areas for fishing and other recreational activities.

(3) Quantitative data on fish populations in both unmitigated and mitigated lakes.

(4) The optimum amount and slope design of shallow, vegetated shoreline habitat that provides productive fish and wildlife habitat at an acceptable cost.

(5) Effect of various amounts of organic matter on water quality and macroinvertebrate community structure.

(6) Effectiveness of standard fish habitat enhancement techniques such as fish shelters, artificial overhanging banks, supplementing shoreline vegetation, addition of spawning substrate, pond fertilization, etc.

LITERATURE CITED

Allison, L. E. 1965. Organic carbon. Pages 1367-1378 in C. A. Black, ed. Methods of soil analysis, Part. 2. American Society of Agronomy, Madison, Wis.

American Public Health Association. 1976. Standard methods for the examination of water and wastewater, 14th ed. American Public Health Association, Washington, D.C. 1,193 pp.

Beaven, T. R., and B. V. McPherson. 1978. Quality of the water in borrow ponds near a major highway interchange, Dade County, Florida, October-November 1977. U.S. Geological Survey Open File Report 78-1029. Tallahassee, Fla.

Canfield, D. E. 1981. Chemical and trophic state characteristics of Florida lakes in relation to regional geology. Final report, contract FWS 14-16-0009, Florida Cooperative Fish and Wildlife Research Unit, Univ. of Florida, Gainesville. 444 pp.

Carlson, R. E. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22:361-369.

Clugston, J. P. 1963. Growth of the Florida largemouth bass, *Micropterus salmoides floridanus* (LeSeru), and the northern largemouth bass, *M. s. salmoides* (Lacepede), in subtropical Florida. Trans. Am. Fish. Soc. 93:146-154.

Council on Environmental Quality. 1978. Our nations wetlands: an inter-agency task force report. U.S. Government Printing Office 0-251-726. 70 pp.

Dineen, J. W. 1964a. Fish population study of five Everglades canals. Federal Aid in Fish Restoration Project F-16-R. Job 1-B. Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Fla.

Dineen, J. W. 1964b. Bottom study of the Florida Everglades and associated canals. Federal Aid in Fish Restoration Project F-16-R. Job 1-B. Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Fla.

Dineen, J. W. 1965. Fish population study of the Florida Everglades. Federal Aid in Fish Restoration Project F-16-R. Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Fla.

Dineen, J. W. 1974. The fishes of the fresh water Everglades. Pages 375-385 *in* P. S. Gleason, ed. Environments of south Florida: present and past. Memoir 2: Miami Geological Society. Miami, Fla.

Edgerton, C. D. 1974. Effects of urbanization upon the availability of construction minerals in SE Florida. U.S. Department of Interior, Bureau of Mines. Inf. Circ. 8664.

Environmental Protection Agency. 1978. A compendium of lake and reservoir data collected by the National Eutrophication Survey in Eastern, North-central and Southeastern United States. Working Paper 475. National Eutrophication Survey, Corvallis, Oreg.

Environmental Science and Engineering. 1979. Evaluation of water resource impacts of four excavations in south Florida. Environmental Science and Engineering, Inc., Gainesville, Fla.

Federal Register. 1981. Part III, Department of the Interior: Fish and Wildlife Service: U.S. Fish and Wildlife Service Mitigation Policy. 46(15), Friday, January 23.

Flannery, M. S., R. D. Snodgrass, and T. J. Whitmore. 1982. Deepwater sediments and trophic conditions in Florida lakes. Hydrobiologia 92: 597-602.

Florida Game and Fresh Water Fish Commission. 1968. Final report: determination of effects of ditching and diking. Federal Aid in Fish Restoration Project F-16-R. Job 1E. West Palm Beach, Fla.

Florida Game and Fresh Water Fish Commission. 1975. Tigertail fish management area. Pages 66-71 *in* Annual report Everglades Region. West Palm Beach, Fla.

Florida Game and Fresh Water Fish Commission. 1978. Snook introduction - stocking and monitoring. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Florida Game and Fresh Water Fish Commission. 1979. Snook introduction. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Florida Game and Fresh Water Fish Commission. 1980. Snook introduction, stocking and monitoring. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Hach Chemical Company. 1975. Water and wastewater analysis procedures. 3rd ed. Hach Chemical Company, Ames, Iowa.

Hanson, J. M., and W. C. Leggett. 1982. Empirical prediction of fish biomass and yield. Can. J. Fish. Aquat. Sci. 39:257-263.

Huish, M. T. 1949. Food habits of three centrarchidae in Lake George, Florida. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 11:293-302.

Jackson, D. F., and F. R. Maurrasse. 1976. Man-made lakes of Dade County--friends or foes? An environmental assessment. Florida International University, Miami, Fla.

Johansson, S.A.E., and T. B. Johansson. 1976. Analytical applications of particle-induced x-ray emission. Nucl. Instrum. Methods 137:473-516.

Kautz, R. S. 1980. Effects of eutrophication on the fish communities of Florida lakes. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 34:67-80.

Kushlan, J. A. 1974. Quantitative sampling of fish populations in shallow, freshwater environments. Trans. Am. Fish. Soc. 103(2):348-352.

Kushlan, J. A., and T. E. Lodge. 1974. Ecological and distributional notes on the freshwater fish of southern Florida. Fla. Sci. 37(2):110-128.

Maenhaut, W., L. DeReu, H. A. Van Rinesvelt, J. Cafeneyer, and P. Van Espen. 1980. Particle-induced x-ray emission (PIXE) analysis of biological materials: precision, accuracy and application to cancer tissues. Nucl. Instrum. Methods 168:557-562.

Mason, W. T., Jr., ed. 1982. Research on fish and wildlife habitat. Off. Res. and Dev., U.S. Environmental Protection Agency. EPA 600/8-82-022. 248 pp.

Mclane, W. M. 1948. The seasonal food of the largemouth bass (Micropterus salmoides) in the St. Johns River, Welaka, Florida. Fla. Acad. Sci. 10(4):102-138.

Merritt, R. W., and K. W. Cummins, eds. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Miller, W. L. 1975. Nutrient concentrations of surface waters in southern Florida, September 1970 to April 1975. U.S. Geological Survey, Open File Report. Tallahassee, Fla.

Miller, W. L. 1978. Effects of bottom sediments on infiltration from the Miami and tributary canals to the Biscayne aquifer, Dade County, Florida. Water-Resources Investigations 78-36. U.S. Geological Survey, Tallahassee, Fla.

Moyer, E. J., and V. P. Williams. 1982. Macroinvertebrate production in box cut access channels versus natural vegetated lake bottom. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 36:(in press).

Northcote, T. G., and Wilkie, D. W. 1963. Underwater census of stream fish populations. Trans. Am. Fish. Soc. 92(2):146-151.

Oglesby, R. T. 1977. Relationships of fish yield to lake phytoplankton standing crop, production, and morphoedaphic factors. J. Fish. Res. Board Can. 34:2771-2279.

Ostle, B., and R. W. Mensing. 1975. Statistics in research. Iowa State Univ. Press, Ames. 595 pp.

Pope, R. L. 1967. A qualitative and quantitative study of the plankton communities in two limestone quarry lakes, Dade County, Florida. M.S. Thesis. Univ. of Miami, Miami, Fla.

Pope, R. L. 1976. Dade County lake study (unpublished data). Dr. R. L. Pope, Miami-Dade Community College (South Campus), Miami, Fla.

Prentki, R. T., T. D. Gustafson, and M. S. Adams. 1978. Nutrient movements in lakeshore marshes. Pages 169-194 in R. E. Good, D. F. Whigham, and R. L. Simpson, eds. Freshwater wetlands: ecological processes and management potential. Academic Press, New York.

Rhoads, P. B. 1969. A study of the phytoplankton primary production and plankton ecology of a shallow, artificial lake, Miami, Florida. M.S. Thesis. Univ. of Miami, Miami, Fla.

Russo, T. N. 1974. Indicators of organic contamination in Plantation Canal, Broward County, Florida 1971-72. Report of investigations No. 70. Florida Dep. of Natural Resources, Bureau of Geology.

Sloey, W. E., F. L. Spangler, and C. W. Fetter, Jr. 1978. Management of freshwater wetlands for nutrient assimilation. Pages 321-340 in R. E. Good, D. F. Whigham, and R. L. Simpson, eds. Freshwater wetlands: ecological processes and management potential. Academic Press, New York.

Sonntag, W. H. 1980. Water quality data for canals in eastern Broward County, Florida, 1975-78. U.S. Geological Survey, Open File Report 80-68. Tallahassee, Fla.

Steward, K. K. 1976. Physiological edaphic and environmental characteristics of typical stands of sawgrass. Aquatic Ecology Newsletter 9:22-23.

Stutzman, K. L. 1980. Issues in fish and wildlife planning: Water resources planning under the Fish and Wildlife Coordination Act. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-80/44. 44 pp.

Swanson, G. A. (Tech. Coord.). 1979. The mitigation symposium: a national workshop on mitigating losses of fish and wildlife habitats. U.S. For. Serv. Rocky Mt. For. Range Exp. Stn., Gen. Tech. Rep. RM-65. 684 pp.

Taubert, B. D., and J. S. Tranquilli. 1982. Verification of the formation of annuli in otoliths of largemouth bass. Trans. Am. Fish. Soc. 111: 531-534.

U.S. Army Corps of Engineers. 1977. Joint permit application for dredge fill, structures: State of Florida. U.S. Army Corps of Engineers, Jacksonville Office, Jacksonville, Fla. 23 pp.

U.S. Army Corps of Engineers. 1981. Environmental assessment of the environmental impacts of limestone rockmining in Dade, Broward and Collier Counties, Florida. U.S. Dep. of the Army, Army Corps of Engineers, Jacksonville District, Jacksonville, Fla.

U.S. Army Corps of Engineers. 1982. Excavation and use of limestone in south Florida. Environmental impact statement. Jacksonville District, Corps of Engineers, Jacksonville, Fla.

Waller, B. G. 1976. Analysis of selected benthic communities in the Florida Everglades with reference to their physical and chemical environment. U.S. Geological Survey Water-Resources Investigations 76-28. Tallahassee, Fla.

Waller, B. G. 1981. Water-quality data for selected stations in the east Everglades, Florida. U.S. Geological Survey, Open File Report 81-821. Tallahassee, Fla.

Wegener, W., and D. Holcomb. 1972. An economic evaluation of the 1970 fishery in Lake Tohopekaliga, Florida. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:628-634.

Wegener, W., D. Holcomb, and V. Williams. 1973. Sampling shallow water fish populations using the Wegener ring. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 27:663-673.

Wegener, W., V. Williams, and T. D. McCall. 1974. Aquatic macroinvertebrate responses to an extreme drawdown. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 28:126-144.

Werner, E. E., D. J. Hall, D. R. Laughlin, D. J. Wagner, L. A. Wilsmann, and F. C. Funk. 1977. Habitat partitioning in a freshwater fish community. J. Fish. Res. Board Can. 34:360-370.

Weinberg, M., D. Reece, and D. Allman. 1980. Effect of urban storm water runoff to a man-made lake on ground water quality. Techn. Publ. 80-4. South Florida Water Management District, West Palm Beach, Fla.

APPENDIX A

Vegetation and Water Quality Data from Study Lakes

Table A1. Occurrence of vegetation in the vicinity of eight limestone excavation lakes, Dade County, Florida.

Species name	Common name	Lake (see Table 1 for location)							
		1	2	3	4	5	6	7	8
Anacardiaceae									
Schinus terebinthifolius	Brazilian pepper		✓	✓	✓	✓		✓	✓
Apiaceae									
Centella asiatica	Pennywort					✓			✓
Hydrocotyle umbellata	Water pennywort			✓		✓			✓
Asclepiadaceae									
Asclepias tuberosa	Butterfly weed		✓						
Asteraceae									
Ambrosia artemisiifolia	Ragweed					✓			✓
Baccharis angustifolia	Salt-bush	✓	✓	✓	✓	✓			✓
Bidens sp.	Beggar ticks	✓	✓		✓	✓		✓	✓
Erigeron sp.	-		✓	✓				✓	
Eupatorium capillifolium	Dogfennel	✓			✓	✓			✓
Lactuca sp.	Wild lettuce	✓							
Makania scandus	Climbing hempweed				✓	✓			✓
Parthenium integrifolium	Parthenium ragweed					✓			✓
Pluchea symphytifolia	Marsh fleabane	✓	✓	✓	✓	✓		✓	✓
Solidago sp.	-		✓	✓	✓	✓		✓	✓
Casuarinaceae									
Casuarina equistifolia	Australian pine	✓	✓	✓	✓			✓	
Convolvulaceae									

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Ipomoea sp.	Morning glory				✓	✓			✓
Cycadaceae									
Zamia integrifolia	Coontie				✓	✓			✓
Cyperaceae									
Carex sp.	Sedge	✓		✓	✓	✓		✓	✓
Cladium jamaicense	Sawgrass			✓	✓	✓		✓	✓
Scripus validus	Soft-stem rush		✓	✓			✓	✓	
Scripus sp.	Bulrush		✓	✓	✓	✓	✓	✓	✓
Euphorbiaceae									
Ricinus communis	Castor-bean							✓	
Fabaceae									
Cassia fasciculata	-					✓			✓
Melilotus alba	White clover					✓			✓
M. officinalis	Yellow clover					✓			✓
Hypericaceae									
Hypericum sp.	St. John's wort				✓				
Juncaceae									
Juncus effusus	Soft rush				✓	✓			✓
Malvaceae									
Sida rhombifolia	-				✓	✓		✓	✓
Melastomataceae									
Rhexia lutea	Meadow-beauty					✓			✓

Table A1. (concl)

Species name	Common name	Lake (see Table 1 for location)							
		1	2	3	4	5	6	7	8
Myricaceae									
Myrica cerifera	Wax myrtle								
Myrtaceae									
Melaleuca quinquenervia	Punk trees		✓					✓	
Poaeceae									
Andropogon sp.	Bluestem	✓	✓		✓	✓		✓	✓
Aristida oligantha	Prairie threeawn								
A. spiciformis	Bottlebush threeawn								
A. stricta	Wiregrass		✓	✓		✓		✓	✓
Axonopus affinis	Carpetgrass					✓			✓
Chloris petraea	Fingergrass	✓	✓	✓	✓	✓		✓	✓
Cynodon dactylon	Bermudagrass						✓		
Dactyloctenium aegyptium	Crowfootgrass				✓				
Eragrostis ciliaris	Annual lovegrass							✓	
Eragrostis sp.	Lovegrass	✓	✓						
Eleusine indica	Goosegrass					✓		✓	✓
Eremochloa ophiuroides	Centipedegrass				✓				
Erianthus gigantia	Giant Cane			✓				✓	
Leersia hexanda	Cutgrass							✓	
Panicum hemitomon	Maidencane	✓						✓	
P. maximum	Guineagrass				✓			✓	
P. repens	Torpedograss				✓			✓	
Paspalum nodatum	Bahiagrass				✓		✓		
P. urvillei	Vaseygrass	✓			✓		✓		
Pennisetum purpureum	Elephantgrass				✓			✓	✓
Rhynchelytrum repens	Natalgrass				✓				
Setaria geniculata	Knotroot bristlegrass	✓			✓	✓			✓

Sorghum halepense	Johnsongrass								
Spartina bakeri	Smooth cordgrass				✓				
Sporobolus indices	Smutgrass	✓			✓	✓			✓
Pteridaceae									
Pteridium aquilinum	Bracken fern					✓			✓
Rubiaceae					✓				
Cephalanthus occidentalis	Buttonbush								
Salicaceae									
Salix caroliniana	Coastal plain willow		✓		✓	✓		✓	✓
Taxodiaceae									
Taxodium distichum	Bald cypress					✓			✓
Typhaceae									
Typha sp.	Cattail		✓	✓	✓	✓	✓	✓	✓
Verbenaceae									
Avicennia germinanus	Black mangrove				✓				
Lippia nodiflora	Frogfruit	✓	✓			✓		✓	✓

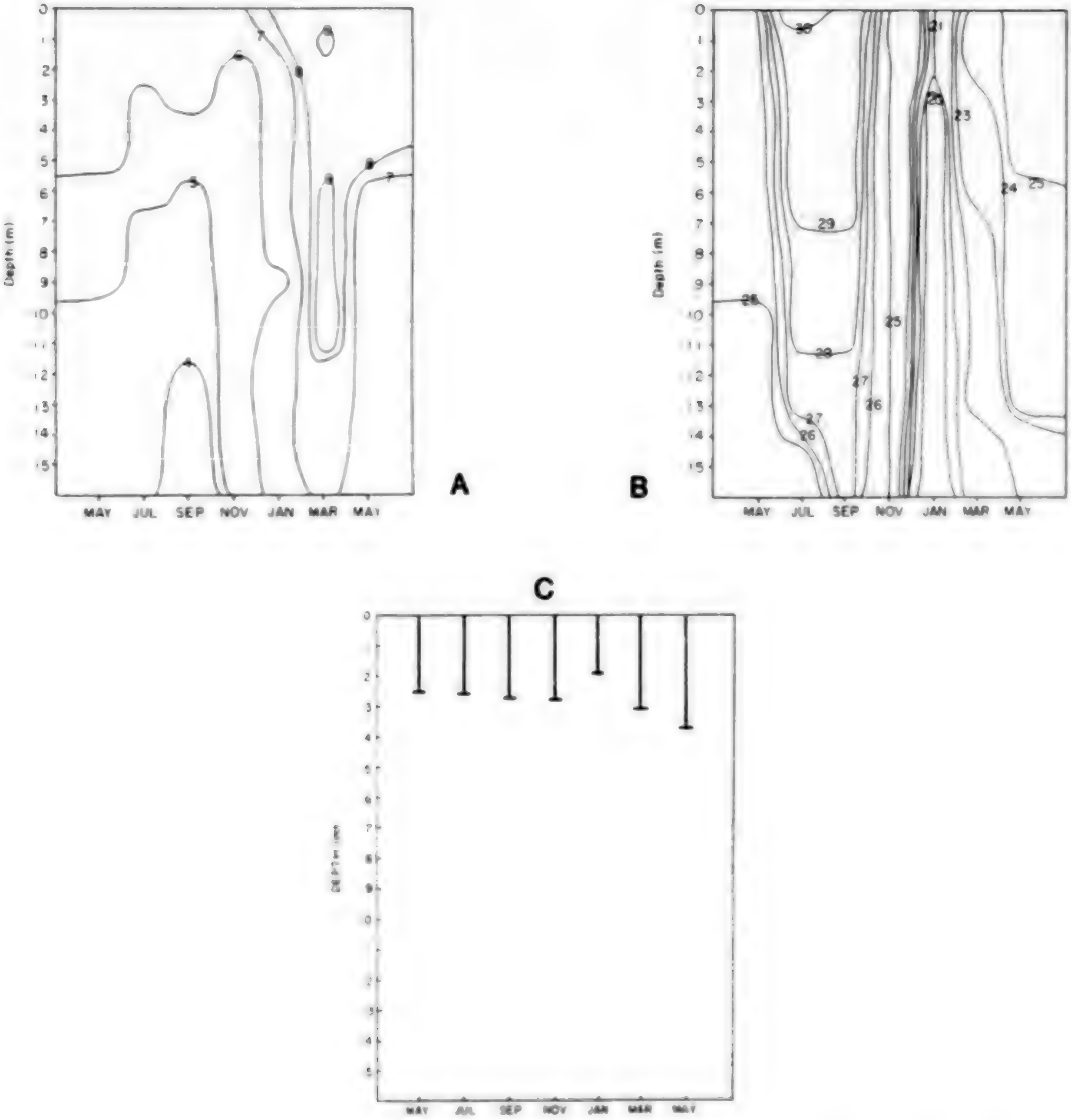

Figure A1. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 1, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

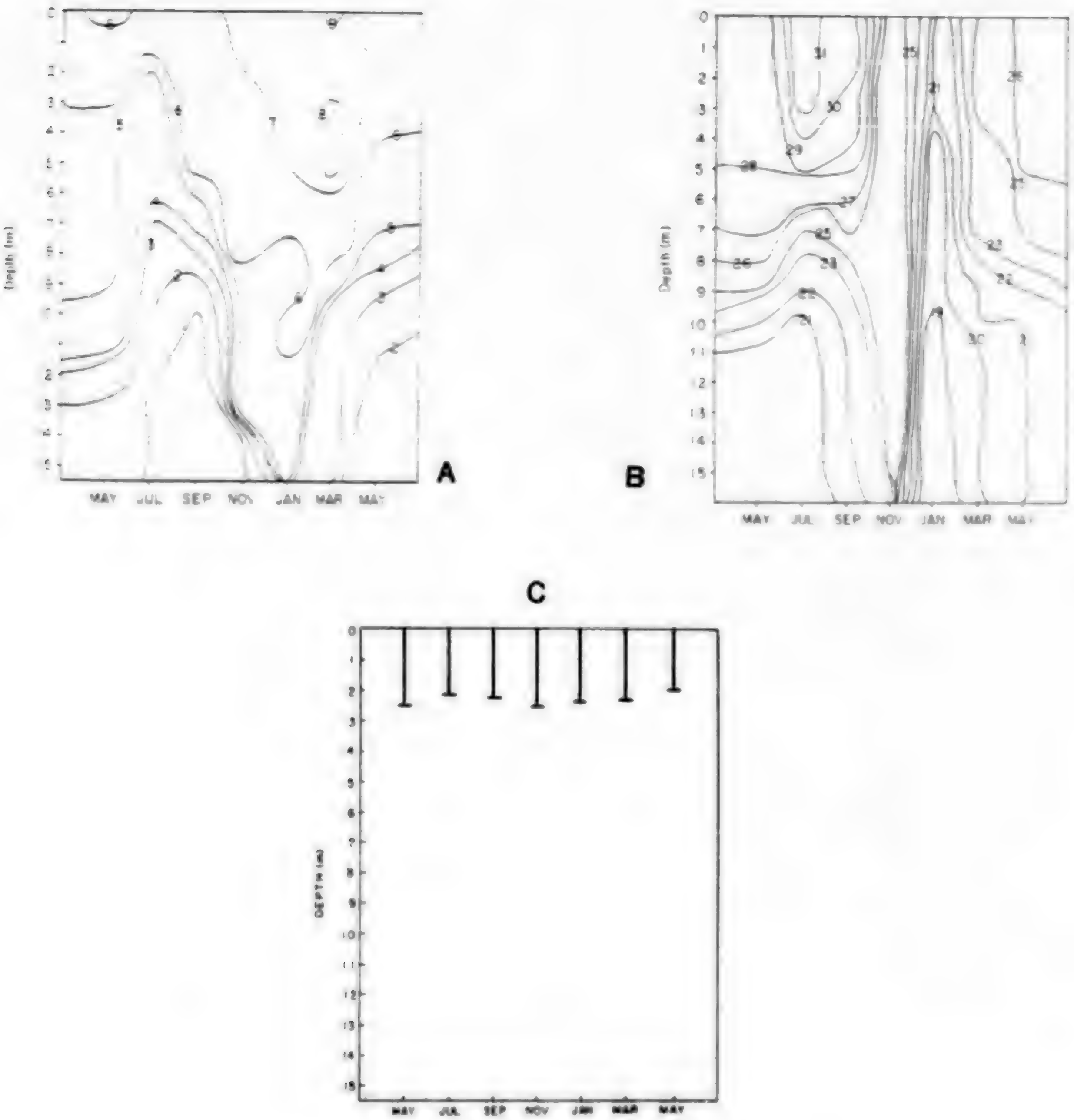

Figure A2. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 2, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

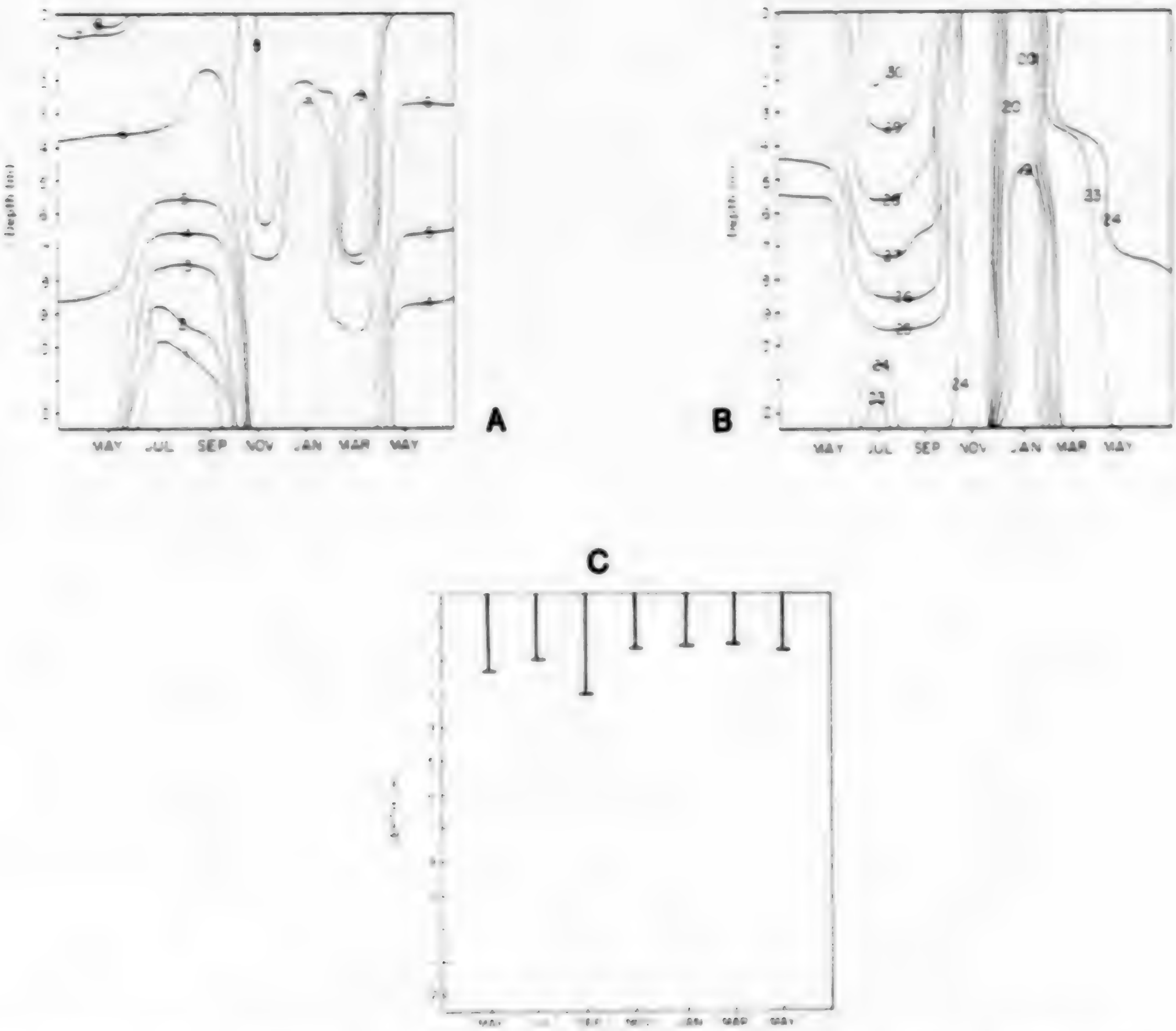

Figure A3. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 3, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

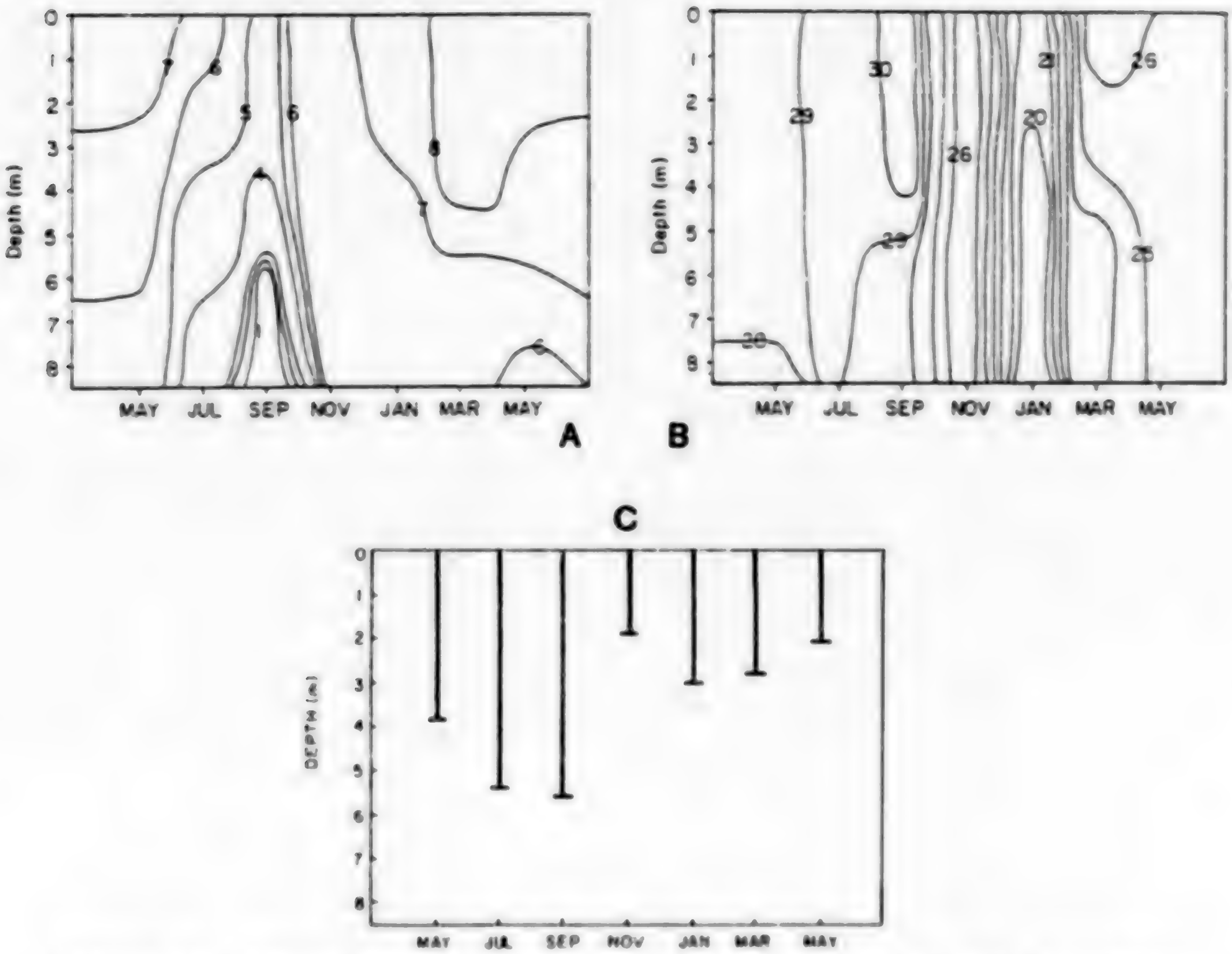

Figure A4. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 4, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

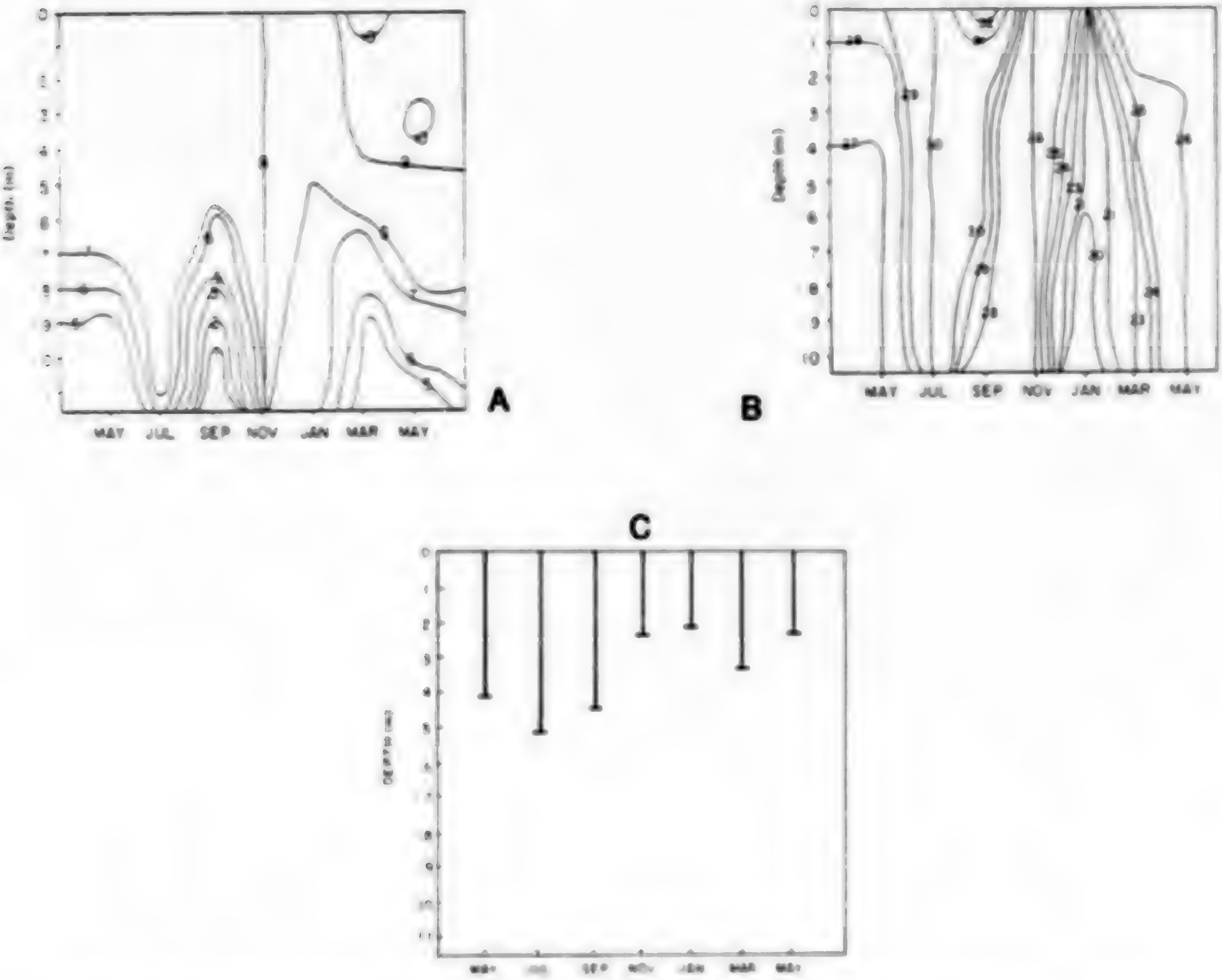

Figure A5. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 5, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

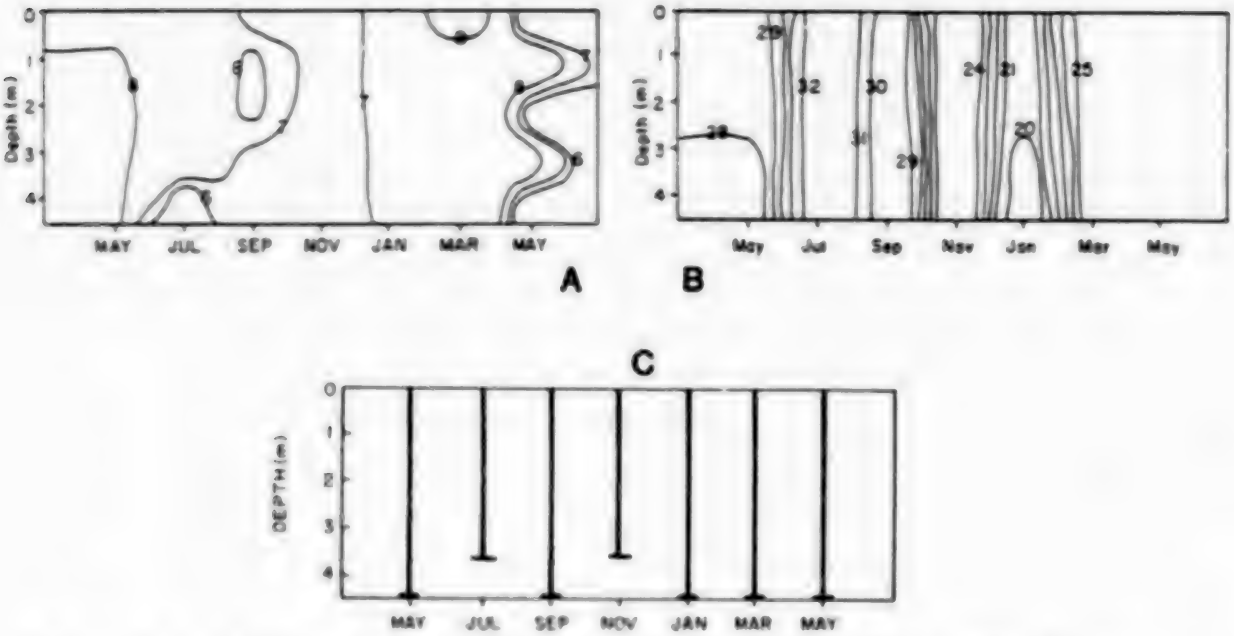

Figure A6. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 6, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

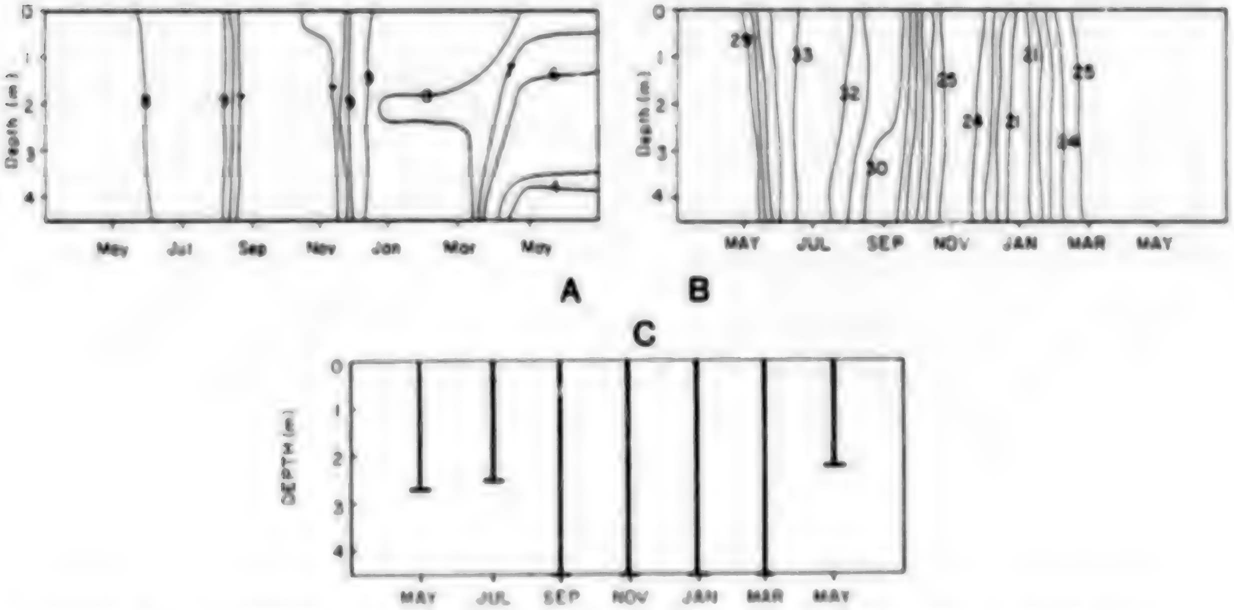

Figure A7. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 7, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

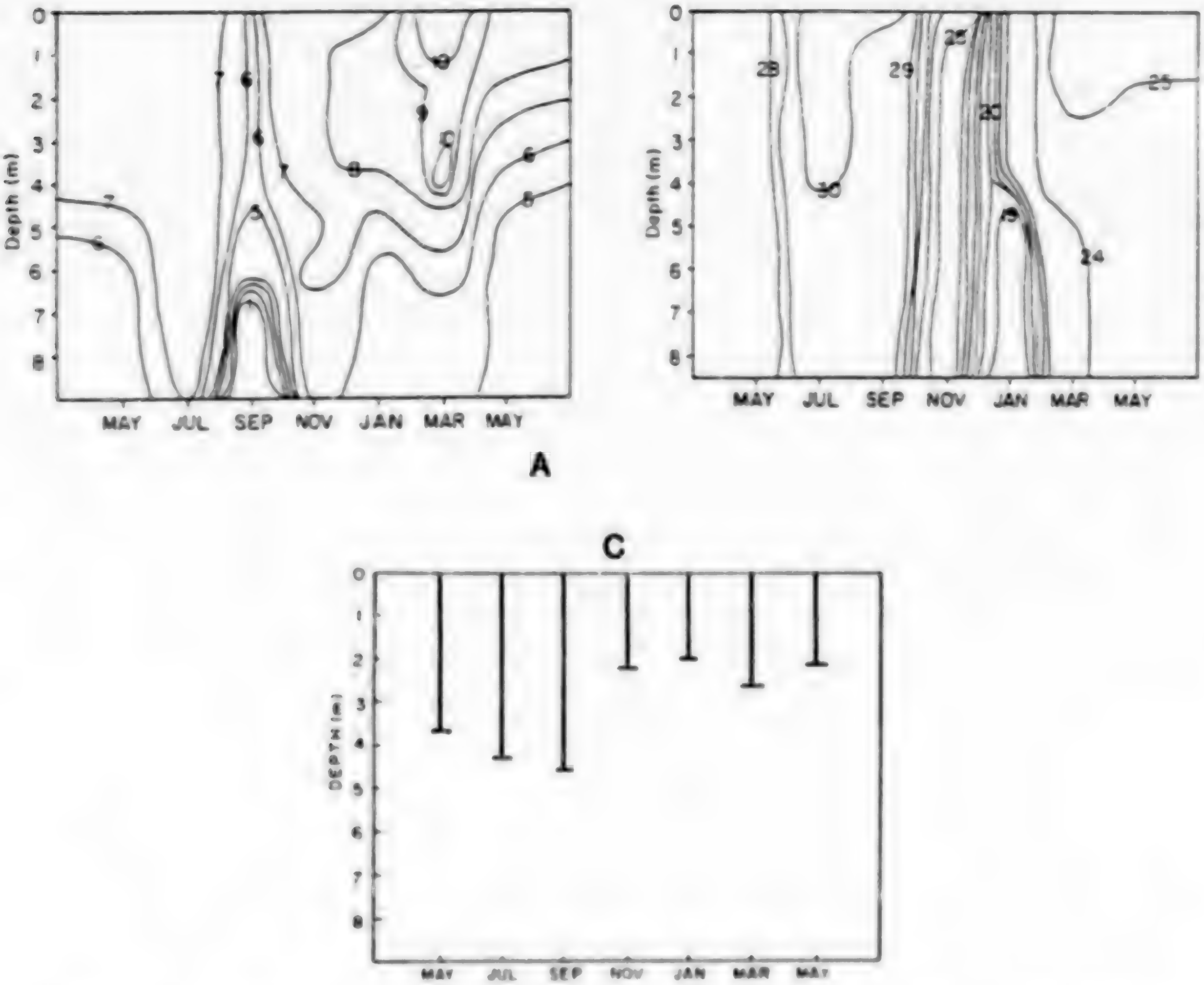

Figure A8. Seasonal variations in (A) dissolved oxygen (mg/l) isopleths, (B) water temperature isotherms, and (C) water transparencies (m) in limestone excavation lake 8, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

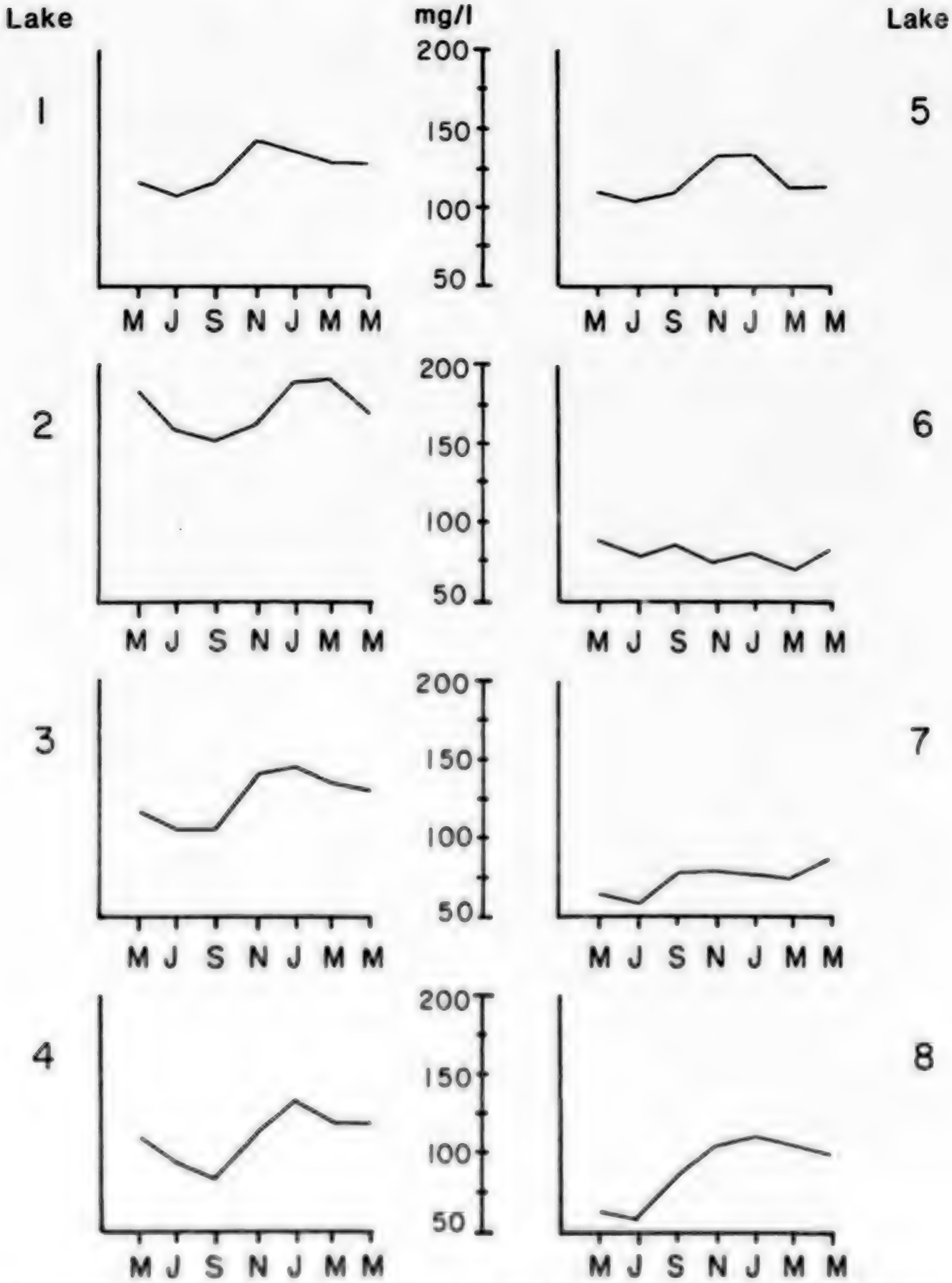

Figure A9. Annual variations i[illegible]otal alkalinity (mg/l) in eight limestone excavation lakes, [illegible]e County, Florida. Data collected bimonthly May 1981 - May 198[illegible] see Table 1 for lake descriptions).

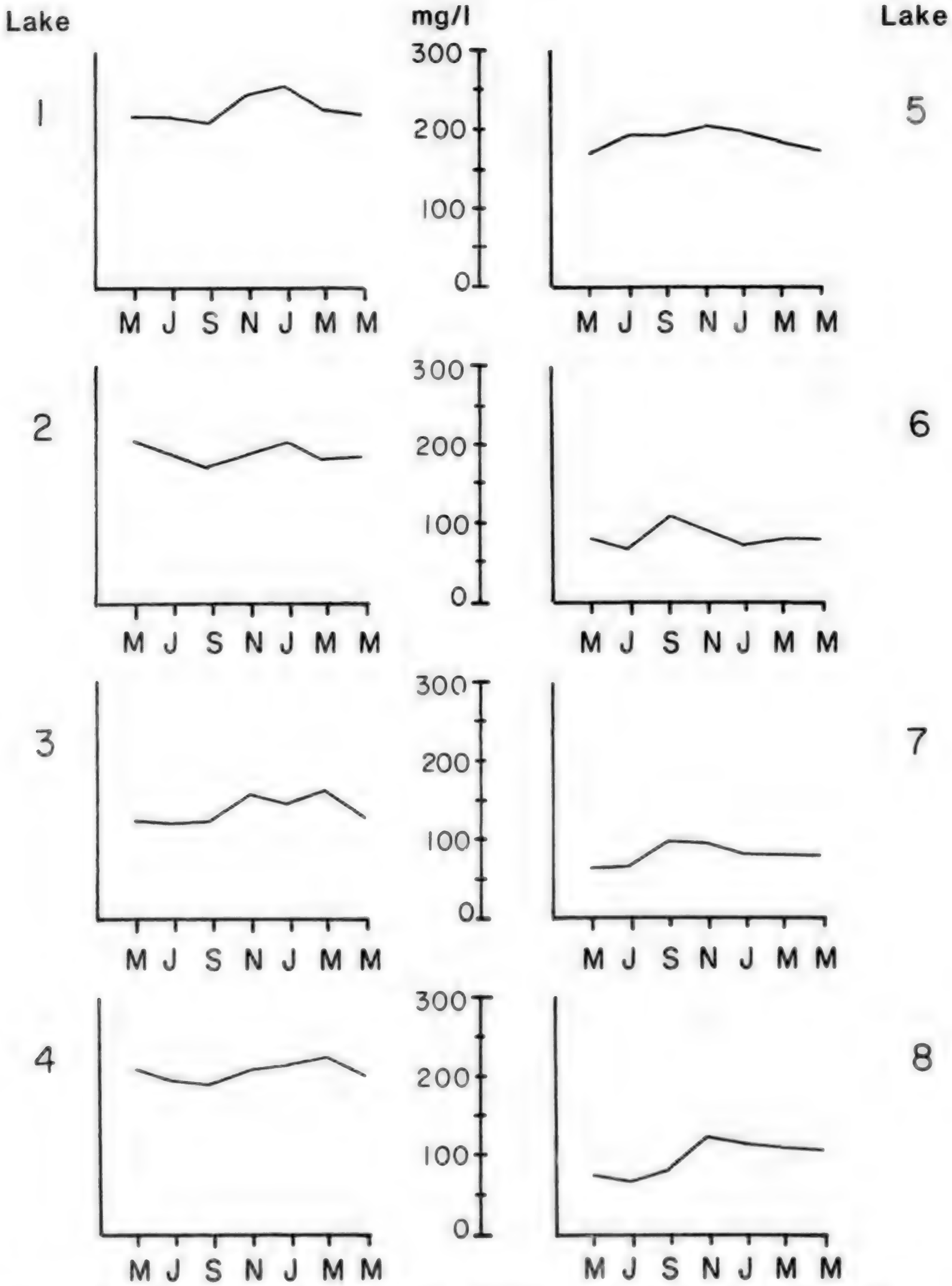

Figure A10. Annual variations in total hardness (mg/l) in eight limestone excavation lakes, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

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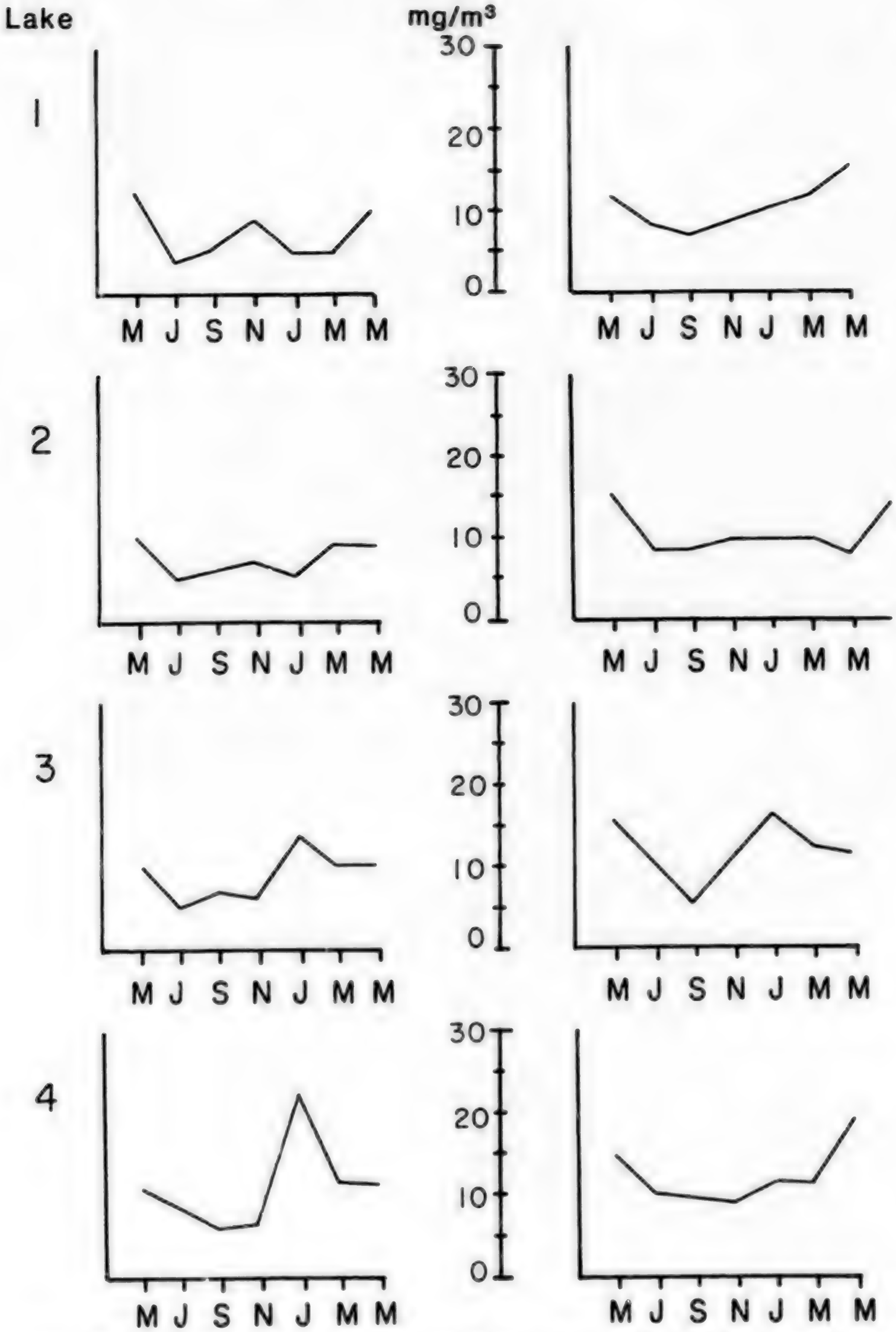

Figure A11. Annual variations in total phosphorus (mg/m^3) in eight limestone excavation lakes, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

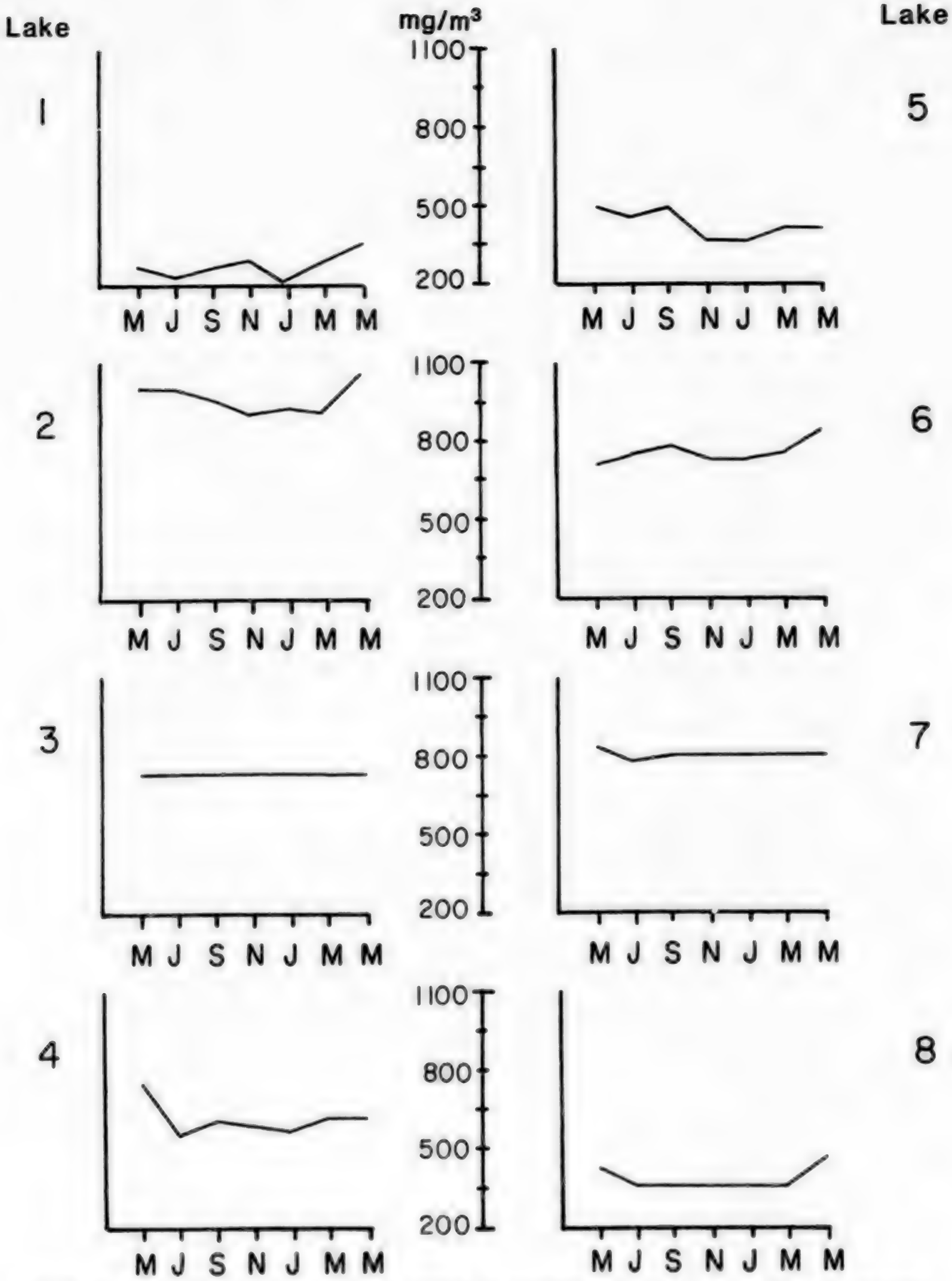

Figure A12. Annual variations in total nitrogen (mg/m³) in eight limestone excavation lakes, Dade County, Florida. Data collected bimonthly May 1981 - May 1982 (see Table 1 for lake descriptions).

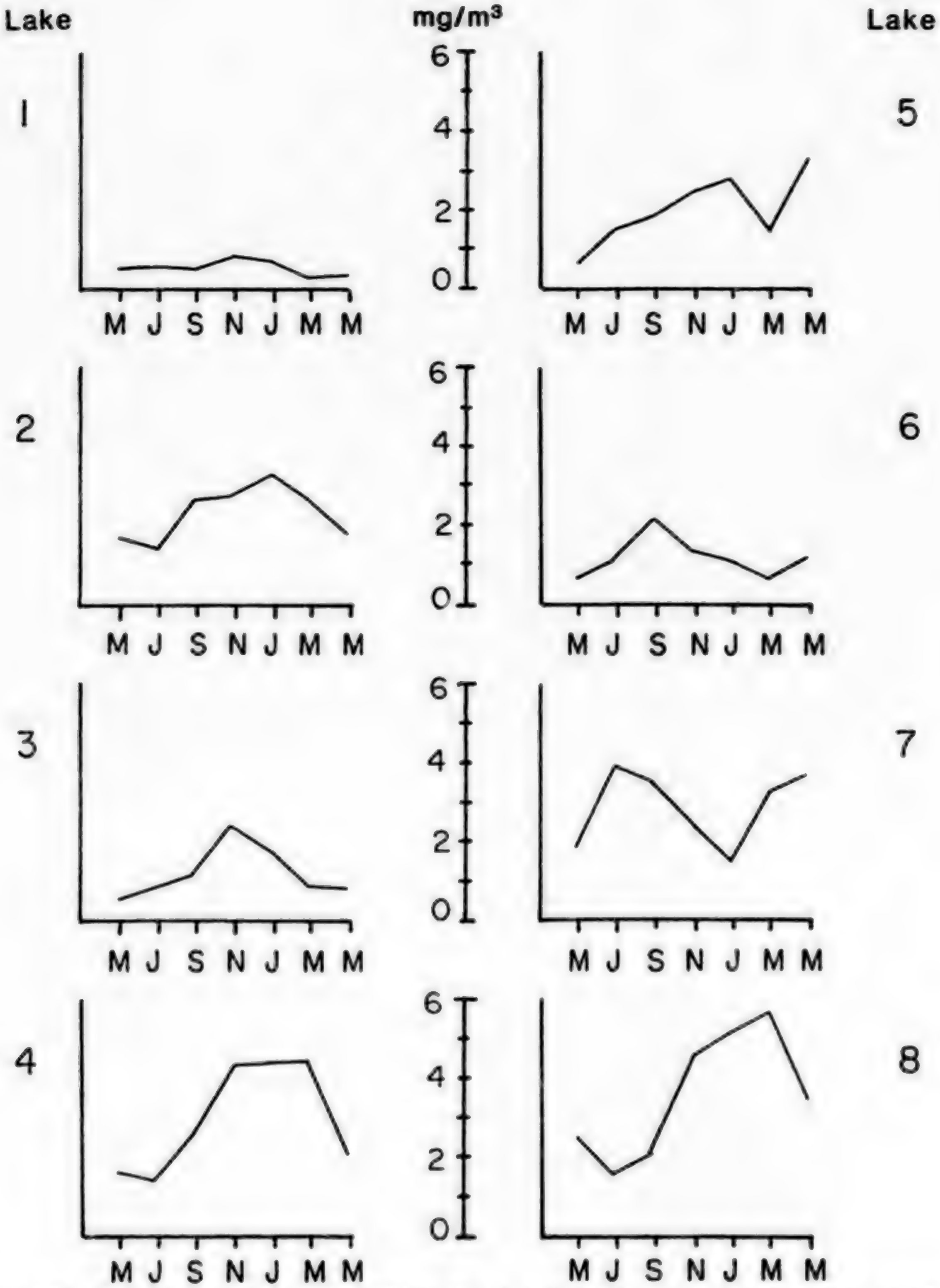

Figure A13. Annual variations in chlorophyll a (mg/m³, no phaeothytin correction made) in eight limestone excavation lakes, Dade County, Florida. Data collected bimonthly May 1981-May 1982 (see Table 1 for lake descriptions).

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APPENDIX B

Annotated Bibliography on Mitigation of Fish and Wildlife Values in Rock-Mined Areas of South Florida

REFERENCES BY MAJOR SUBJECT CATEGORIES

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I. SUPPLY AND DEMAND

A. Rock-mining

Aase, G. 1962. Feasibility study of a proposed Portland cement industry in redevelopment area A, West Florida. Aase and Associates, Inc., Tallahassee, Fla. (1)

All raw materials needed for cement manufacture can be delivered to any of several possible plant sites in Area A, at prices which will permit economical and competitive production of cement. Reserves of raw materials are sufficient to sustain a cement plant of the capacity considered in this report throughout the operating life of the plant. Generally within a 200-mile radius of the proposed plant site, there exists a steady and moderately increasing cement market of approximately 2,470,000 barrels per year. Largely because of freight advantages due to shorter transportation distances, the proposed Area A plant could expect to command a share of this local market amounting to approximately 940,000 barrels per year. A plant operating at a minimum capacity of 1,213,000 barrels per year would be necessary to enable a low enough unit production cost to be competitive with existing sources of cement supply in the area.

Aase, G., F. Andrews, N. Landrum, and E. Bishop. 1962. Feasibility study of a proposed lime industry in redevelopment area A, West Florida. Aase and Associates, Inc., Tallahassee, Fla. (2)

Raw material needed for lime production can be delivered to any of several possible plant sites at prices which will permit economical and competitive production of quick and hydrated lime. Because of the advantages of lower transportation costs, a Marianna plant could compete successfully in a large primary market area. Because of local deficiencies of supply, a Marianna plant could expect a measure of success in a broader secondary market area even without distinct transportation advantages. The combined reported consumption in both market areas is an estimated 755,000 tons per year, of which a Marianna plant could expect to capture about 80,000 tons. A Marianna plant would enjoy a fairly strong price position which should give it flexibility in competing for markets while at the same time assuring an ample margin of profit. It appears that a lime plant of about 80,000 tons per year capacity would be a successful and profitable business venture.

Edgerton, C. D. 1974. Effects of urbanization upon the availability of construction minerals in SE Florida. U.S. Department of Interior, Bureau of Mines. Inf. Circ. 8664. (3)

Miami Oolite limestone is the only significant construction mineral in southeastern Florida. Although two-thirds of the existing resource is unavailable because of urban development, demand for many years can still be met if further extraction is not restricted. It is estimated (1972) that the demand in 1985 will be 33 million tons annually and that 10.2 mi^2 will be required to yield the necessary limestone through 1985.

Hancock, H. M. 1965. Computation of borrow pit quantities. Bureau of Public Roads, Div. of Development, Washington, D.C. (4)

Computer program that determines the volume of material removed from a borrow pit directly from preliminary and final cross-section notes with a minimum of processing. First the volume of earth between the original ground surface and an arbitrary horizontal datum plane is determined, then the volume between the final ground surface and the same horizontal datum plane is determined. The difference between these two volumes is the volume of the material removed.

Schmidt, W., R. W. Haenstine, M. S. Knapp, E. Lane, G. M. Ogden, Jr., and T. M. Scott. 1979. The limestone, dolomite and coouina resources of Florida. U.S. Geological Survey Report of Investigations 88. Tallahassee, Fla. (5)

Data relating to the occurrence of the limestone, dolomite, and coquina resources in Florida and the uses of these commodities. The report includes sections on uses of limestone, market trends, mining methods, and a list of mineral producers and mine locations.

Trauffer, W. E. 1975. Model new Florida crushed stone plant. Pit and Quarry. August:56-66. (6)

U.S. Department of the Interior. 1973. Resource and land information for south Dade County, Florida. U.S. Geol. Survey Invest. I-850. (7)

Topics include physical setting, urbanization, natural hazards, mineral resources, managing the water system, environmental quality, outdoor recreation, Everglades National Park, coastal zone, fish and wildlife and Miccosukee Indians. Limestone is recognized as the principal mineral resource with an estimated 32 billion tons available. The demand for crushed limestone has paralleled the population growth of the area. In 1971, 21.3 million tons of limestone was quarried in Dade and Broward counties.

(Other references relating, in part, to rock-mining supply and demand include 31).

B. General, South Florida

Dambaugh, L. N. 1962. Land use in Dade County, Florida. Fla. Acad. Sci. 25(1):29-44. (8)

Provides historical data on the agricultural-urban development of the area. Costs of filling land listed as averaging $1,200 - $2,000 per foot per acre.

Seamen, W., and R. Mclean. 1977. Freshwater and the Florida coast: southwest Florida. Proceedings of a seminar for Southwest Rep. 1977-1. Florida Water Management District, Tampa, Fla. (9)

Limerock mining consumes the second largest water use (phosphate is first) in the region with a 1975 water demand of 86 million gallons a day. Limerock mining water requirements are expected to increase to 110 million gallons a day in the mid-1980's.

Sweeney, J. W., and C. W. Hendry, Jr. 1978. Minerals in the economy of Florida. U.S. Department of the Interior, Bureau of Mines. State Mineral Profiles SMP-4. (10)

In 1978 Florida was the 6th largest producer of non-fuel minerals at a value of approximately $1 billion. The cement industry had a production value of greater than $110 million while the stone industry was $118 million.

(Another reference relating, in part, to supply and demand is 159).

II. REGULATIONS, MITIGATION

A. Rock-mining

Department of Environmental Resource Management, Dade County. 1980. Criteria for lake excavations in Dade County, DERM 80-2. Miami, Fla. (11)

Criteria used to review applications for lake excavations in Dade County. Objectives of the guidelines are to protect the integrity of the drinking water supply and to minimize the eutrophication of lakes.

Pridgen Engineering Company, Inc. 1975. Florida Rock Industries proposed plan of operation for the Citrus County mine. Pridgen Engineering Company, Inc., Lakeland Fla. (12)

Detailed plan of operation including site preparation, mining and reclamation for a limestone mining site in central Florida.

Rickert, D. A., and A. M. Spieker. 1971. Real-estate lakes, water in the urban environment. U.S. Geol. Surv. Circ. 601-G. (13)

Nationwide examination of the types and characteristics of real-estate lakes. Includes the planning and management of real-estate lakes and the reclaiming of abandoned quarries and pits.

Southern District Florida. 1970. Coastal Petroleum Co. vs. Secretary of the Army (non-navigational grounds for denial of permit to mine in navigable lake bed) 315 Federal Supplement 845-850. (14)

Plaintiff Mining Company sued to compel defendant secretary of the army to issue a permit to mine limestone in Lake Okeechobee, a navigable lake. Plaintiff contended that it had a legal right to mine under leases from the State and that defendant could not deny a permit since there had been no finding that the mining would interfere with navigation. Defendant contended that it could deny the permit in view of the mining's detrimental effect on wildlife and the danger of saline intrusion into the lake, a major fresh water supply for the State. Defendant also argued that limestone was not within the terms of the mineral leases from the State. The court held that defendant could not deny a permit for other than navigational reasons and that the validity of the mining leases as in limestone had already been established by State court decisions. However, the court refused to order the issuance of the permit because of the potential harm to the public interest. Plaintiff's remedy was damages for its loss of profits.

U.S. Army Corps of Engineers. 1977. Joint Permit Application for Dredge Fill, Structures. - State of Florida. U.S. Army Corps of Engineers, Jacksonville Office, Jacksonville, Fla. (15)

An information and application packet for construction, dredging and filling in the waters of Florida. Includes (1) what activities require a permit (2) how applications are processed, (3) additional procedures, (4) specific instructions and requirements, (5) appendices. The appendices include applications, exemptions, addresses, illustrative maps and figures, questions and answers.

U.S. Army Corps of Engineers. 1981. Environmental assessment of the environmental impacts of limestone rock-mining in Dade, Broward and Collier Counties, Florida. U.S. Dept. of the Army, Army Corps of Engineers, Jacksonville, District, Jacksonville, Fla. 32201. (16)

Initiated to provide programmatic tool to aid the Corps of Engineers in the review and issuance of future permits for rockmining.

Major headings in the 257 page report include:
(1) Purpose and need for the assessment
(2) Alternatives
(3) Existing environmental conditions
(4) Potential environmental impacts
(5) Unavoidable adverse environmental impacts
(6) Short-term vs. long-term impacts
(7) Irreversible and irretrievable commitments of resources
(8) Considerations that offset environmental effects

(Other references relating to, in part, rock-mining regulations, mitigation include 3, 31, 115).

B. General, South Florida

Bauer, A. M. 1970. A guide to site development and rehabilitation of pits and quarries. Ontario Department of Mines, IMR 33. (17)

Procedures, techniques and information needed for rehabilitation and reclamation plans. Examples from Ontario.

Everglades Recreational Planning Board. 1974. Recreational development of the Florida Everglades water conservation areas: Five-year plan 1973-1978. Submitted to Florida Game and Fresh Water Fish Commission, Tallahassee, Fla. (18)

Plans to meet resource-based outdoor recreation demands in the conservation area.

Florida Department of Air and Water Pollution Control. 1971. Fish values (mimeo). Tallahassee, Fla. (19)

Under amendment of Chapter 70-141, Section 403. 141, Florida Statutes, 1970 Legislature, a table of fish values for fish killed by water pollution.

National Academy of Sciences. 1979. Surface mining of non-coal minerals: a study of mineral mining from the perspective of the Surface Mining Control and Reclamation Act of 1977. (20)

Provides a means for development of the data and analyses necessary to establish effective and reasonable regulation of surface mining operations. Chapters include: Mining and Reclamation Problems, Waste Management and Reclamation Practices, Existing Governmental Controls and Reclamation Requirements, Applicability of the Surface Mining Control and Reclamation Act of 1977 to Non-coal Minerals, Alternative Institutional Approaches for Surface Mining Control and Reclamation.

Leedy, D. L., T. M. Franklin, and R. M. Maestro. 1981. Planning for urban fishing and waterfront recreation. Biological Services Program FWS/OBS-80/35. U.S. Fish and Wildlife Service Contract 14-16-0009-79-1014, Kearneysville, W. Va. (21)

Document intended to help planners and developers enhance fishing and waterfront recreation in urban areas. Includes background information, literature review, and guidelines for preserving and enhancing urban aquatic resources and water related recreational opportunities.

U.S. Army Engineer Waterways Experiment Station. 1978. Preliminary guide to wetlands of peninsular Florida: major associations and communities identified. Environmental Effects Laboratory, Vicksburg, Miss. (22)

Guide to the major plant associations and communities found in wetlands within peninsular Florida. Intended only for use in wetland identification in the implementation of Section 404 of the Federal Water Pollution Control Act, not considered a classification system for other purposes.

(Other references relating to, in part, regulations, mitigation include 161).

III. WATER QUALITY

A. Rock-mining

Beaven, T. R., and B. F. McPherson. 1978. Quality of the water in borrow ponds near a major highway interchange, Dade County, Florida, October-November 1977. U.S. Geological Survey Open File Rep. 78-1029. Tallahassee, Fla. (23)

Water, bottom sediment, and biota were sampled for heavy metals, trace metals, pesticides, and organics. Generally concentrations were within the range expected in uncontaminated environments in south Florida. Lead, chromium, dieldrin, and polychlorinated biphenyls exceeded background levels for Florida in several cases.

Department of Environmental Resource Management. 1980. Depth as a controlling factor of water quality in wilderness lakes in south Dade County. Miami, Fla. (24)

Twenty rockpits (Wilderness lakes) in Dade County, Florida, were inventoried for depth, secchi disk, bottom dissolved oxygen, and phytoplankton population. There was no linear relationship between excavation depth and phytoplankton concentration or bottom DO. Secchi disk was correlated with lake depth. The agency concluded that excavation depth was not a controlling factor for water quality and excavations should not be restricted by depth for water quality purposes.

Environmental Science and Engineering, Inc. 1979. Big Cypress Basin excavation study, basin program #2502. Vol. 1. Executive summary water management guidelines. Gainesville, Fla. (25)

Detailed study of four excavations. Includes analysis of water quality, production, respiration, perimeter vegetation, diversity, and recommendations for design criteria.

Geraghty and Miller, Inc. 1977. Investigation of ground-water conditions at borrow pits 7, 9, and 10 Dade County, Florida. West Palm Beach, Fla. (26)

Characterizes the groundwater quality adjacent to three borrow pits. The authors concluded that differences in the concentrations of nutrients and heavy metals were not significant when adjacent groundwater quality was compared to ground water near the pit.

Haumann, D., and T. D. Waite. 1978. The kinetics of phosphate removal in small alkaline lakes by natural and artificial processes. Water Air Soil Pollut. 10:291-313. (27)

Two small borrow pit lakes were artificially fertilized and then monitored for phosphate removal. Physicochemical processes were found to remove 79.7% to 97.6% of the phosphate. The highest removal by natural processes was 11.1%.

Jackson, D. F., and F. R. Maurrasse. 1976. Man-made lakes of Dade County--friends of foes? An environmental assessment. Florida International University, Miami, Fla. (28)

This assessment is divided into three sections. The first section, Cultural Eutrophication: The number one water quality problem of man-made lakes in Dade County, is an overview of the eutrophication process. The second section is a selected survey of man-made real estate lakes in Dade County. Data collected included location, age, size, uses, value of homes, observed biota, and problems. In the majority of the lakes bass, bream, and ducks were observed. Weed problems were common. The third section is an assessment of the impact of quarry pits on the aquifer in N.W. Dade County. The author concluded that limestone rock removal causes a direct net storage increase of the aquifer. The pits also represent direct and faster infiltration sources and are beneficial in maintaining hydrostatic pressure.

Missimer and Associates, Inc. 1979. Quality of water in the vicinity of the Meekings Inc. Hollywood Rock Mine. Naples, Fla. (29)

The effects of discharging pit water into nearby canals was examined. Water quality parameters of surrounding surface and groundwater resources were similar to those expected. Parameters that exceeded water quality criteria could not be attributed to rock-mining operations. Parameters examined included: heavy metals, pesticides, total and fecal coliform, DO, BOD, organic N, total P, TOC, pH, turbidity, alkalinity, chlorides, fluorides, conductivity, detergents, and oil and grease.

Pope, R. L. 1976. Dade County lake study. (unpublished data). Dr. R. L. Pope, Miami-Dade Community College (South Campus), Miami, Fla. (30)

In this unpublished survey, over 70 pits in Dade County, Florida were sampled. Water quality parameters included hardness, pH, alkalinity, conductivity, dissolved oxygen, transparency, and ion composition. The pits were sampled once in 1969 and again in 1976. The pits ranged in age from 1 to 29 yr, in depth from 4 to 34 ft, and in size from 1 to 35 acres. Water quality means are listed below.

	Hardness (mg/l)	Alkalinity (mg/l)	pH	Conductivity (µmphos)
1969	129	122	7.8	284
1976	151	134	7.7	300

Stangland, H. G., and M. E. Lehman. 1979. Evaluation of water resource impacts of four excavations in south Florida. Environmental Science and Engineering, Inc., Gainesville, Fla. (31)

A summary report of hydrological water quality, ecological, and socioeconomic conditions at four excavations in western Collier County, Florida. Hydrological data included bathymetry, lake levels, groundwater levels, evaporation rates, and water budgets. Water quality included temperature, secchi disk, conductivity, chloride, pH, total organic carbon, dissolved oxygen, total nitrogen, total orthophosphate, chlorophyll, total coliforms, and lake bottom sediments. Ecological data included identification of perimeter vegetation and production estimates. Socioeconomic data was collected on how different side slopes affected the amount of obtainable fill and subsequent cost of excavated material. A formula for maximum depth of excavations is proposed based on dissolved oxygen, wind, and lake morphology.

Waite, T. D., and W. J. Fogarty. 1973. Natural phosphate removal mechanisms in south Florida lakes. Pages 472-481 in Water for the Human Environment, Vol. IV, Special sessions: Proceedings of the First World Congress on Water Resources. Chicago, Ill. (32)

Two small lakes (borrow pits) were artificially fertilized with phosphate. Removal rate of phosphorus was correlated with plant productivity and loss to the sediments. Greater than 50% of the phosphate was removed by chemical precipitation, 9%-50% by macrophyte growth and 0.5%-9% by phytoplankton.

Weinberg, M., D. Reece, and D. Allman. 1980. Effect of urban storm water runoff to a man-made lake on ground water quality. South Florida Water Management District, Tech. Publ. 80-4, West Palm Beach, Fla. (33)

Water quality data (temperature, dissolved oxygen, specific conductance, pH, calcium, chloride, sulfate, alkalinity, COD, copper, total lead, phosphorus, nitrogen) were collected for a rockpit and ground water around the lake for one year. No gross contamination of the ground water by the rockpit was found. Study was inconclusive in determining whether rockpit lakes helped cause degradation of groundwater quality.

(Other references relating to, in part, rock-mining water quality include 11, 16, 137, 138).

B. General South Florida

Buchanan, T. J., and J. H. Hartwell. 1972. Analysis of water level data for the Everglades National Park, Florida. U.S. Geological Survey, Open File Rep. 72004. (34)

Stage duration curves were developed for five gaging stations to reflect the seasonal trends of water level.

Canfield, D. E., Jr. 1981. Chemical and trophic state characteristics of Florida lakes in relation to regional geology. Final Rep. Contract FWS 14-16-0009, Florida Cooperative Fish and Wildlife Research Unit, Univ. of Florida, Gainesville. (35)

Water quality data from 165 lakes representing a broad range of limnological conditions and regions.

Canfield, D. E., Jr. 1981. Prediction of chlorophyll *a* concentrations in Florida lakes: the importance of phosphorus and nitrogen. Florida Agricultural Experiment Station, Center for Aquatic Weeds, Univ. of Florida, Gainesville. Journal Series 3518. (36)

Models for the prediction of chlorophyll *a* concentrations were developed and tested using data on 223 Florida lakes.

Environmental Protection Agency. 1978. A compendium of lake and reservoir data collected by the National Eutrophication Survey in Eastern, North-central, and Southeastern United States. Working Paper 475. National Eutrophication Survey, Corvallis, Oreg. (37)

Data on morphometry, physical and chemical characteristics, biological characteristics, nutrient loading and non-point sources for 40 Florida lakes.

Freiberger, H. J. 1972. Nutrient survey of surface water in southern Florida during a wet and a dry season, September 1970 and March 1971. U.S. Geological Survey Open File Rep. 72008. Tallahassee, Fla. (38)

Occurrence and distribution of nitrogen and phosphorus forms during wet and dry seasons in southern Florida waters.

Gleason, P. J. 1974. Chemical quality of water in conservation area 2A and associated canals. South Florida Water Management District, Tech. Publ. 74-1. West Palm Beach, Fla. (39)

Goolsby, D. A., H. C. Mattraw, A. G. Lamonds, D. V. Maddy, and J. R. Rollo. 1976. Analysis of historical water-quality data and description of plan for a sampling network in central and southern Florida. U.S. Geological Survey, Water Resources Investigations 76-52. (40)

Analysis of water quality parameters from streams, canals and lakes in central and southern Florida.

Hardee, J., R. A. Miller, and H. C. Mattraw. 1978. Stormwater-runoff data for a highway area, Broward County, Florida. U.S. Geological Survey, Open File Rep. 78-612. (41)

Rainfall, stormwater discharge, and water quality data were computed for the runoff from 41 storms.

Hardee, J., R. A. Miller, and H. C. Mattraw. 1979. Stormwater-runoff data for a multifamily residential area, Dade County, Florida. U.S. Geological Survey, Open File Rep. 79-1295. (42)

Rainfall, stormwater discharge, and water-quality data were computed for runoff from 16 storms.

Hull, J. E., and F. W. Meyer. 1973. Salinity studies in East Glades agricultural area, southeastern Dade County, Florida. U.S. Geological Survey, Open File Rep. 73-005. (43)

Saline soils were caused chiefly by brackish ground water moving upward from water table during dry periods. The outlook is for no improvement in saline soil problems unless land use changes significantly, permitting maintenance of higher water levels along the coast to halt the inland movement of sea water.

Klein, H., J. T. Armbruster, B. F. McPherson, and H. J. Freiberger. 1975. Water and the south Florida environment. U.S. Geological Survey Water-Resource Investigations 24-75. Tallahassee, Fla. (44)

The quantity and quality of surface and ground water and their interrelation with estuarine and marine waters are considered in this investigation. Also examined are the problems, present or future, related to the hydrologic environment that involve human, animal, and plant life.

Kolipinski, M., and C. A. Higer. 1969. Some aspects of the effects of the quantity and quality of water on the biological communities of the Everglades National Park. U.S. Geological Survey, Open File Rep. 69-007, Tallahassee, Fla. (45)

The effects of the quantity and quality of water on (1) vegetational changes, (2) population dynamics of animals, and (3) repopulation of small aquatic animals.

Kushlan, J. A. 1974. Effects of a natural fish kill on the water quality, plankton, and fish population of a pond in the Big Cypress Swamp, Florida. Trans. Am. Fish. Soc. 103:235-243. (46)

Physicochemical parameters of water quality varied greatly from the usual range after a fish kill. The fish kill had no long range effects on the limnology of the pond.

Leach, S. D., H. Klein, and E. R. Hampton. 1972. Hydrologic effects of water control and management of southeastern Florida. U.S. Geological Survey Report of Investigations 60. Tallahassee, Fla. (47)

MacVicar, T. K. 1981. Frequency analysis of rainfall maximums for central and south Florida. South Florida Water Management District, Tech. Publ. 81-3. West Palm Beach, Fla. (48)

McPherson, B. F. 1973. Water quality in the conservation areas of the central and southern Florida flood control district, 1970-1972. U.S. Geological Survey Open File Rep. 73-104. Tallahassee, Fla. (49)

Provides background information on seasonal and spatial changes in water quality in the conservation areas. Parameters studied were dissolved solids, trace metals, nitrogen, phosphorus, and pesticides. Pesticide levels were examined in both bottom sediments and centrarchid fish. Parameters varied widely with sample location and season.

Miller, R. A., H. C. Mattraw, Jr., and J. Hardee. 1979. Stormwater runoff data for a commercial area, Broward County, Florida. U.S. Geological Survey Open File Rep. 79-982. Table 1-7. Tallahassee, Fla. (50)

Rainfall, stormwater discharge, and water-quality data for rainfall and runoff are summarized for a commercial area in Fort Lauderdale, Florida. Loads for 20 water-quality constituents were computed for runoff from 31 storms.

Miller, W. L. 1975. Nutrient concentrations of surface waters in southern Florida. September 1970 to April 1975. U.S. Geological Survey, Open File Rep. 75-010. Tallahassee, Fla. (51)

Accumulated nitrogen and phosphorus data of nine nutrient surveys from canals, rivers, lakes, coastal bays, marshes, and swamps.

National Oceanic and Atmospheric Administration. 1976. Climatography of the U.S. No. 20: Climate of Homestead, Florida. National Climatic Center, Asheville, N.C. (52)

Pitt, W. A. J., H. C. Mattraw, and H. Klein. 1975. Groundwater quality in selected areas serviced by septic tanks, Dade County, Florida. U.S. Geological Survey, Open File Rep. 75-607. (53)

Chemical, physical, bacteriological, and virological characteristics of the ground water in areas serviced by septic tanks. Areal variations in the composition and the hydraulic conductivity of the sand and limestone aquifer had the most noticeable influence on the overall groundwater quality.

Sonntag, W. H. 1980. Water quality data for canals in eastern Broward County, Florida, 1975-78. U.S. Geological Survey, Open File Rep. 80-68. (54)

Selected water quality data including pesticide analysis of bottom sediments in primary canals of Broward County.

Wagner, J. I., and P. C. Resendahl. 1982. Structure S-12 water distribution to Everglades National Park. South Florida Research Center Report T-650. Everglades National Park, Homestead, Fla. (55)

Analysis of the distribution of scheduled surface deliveries through the S-12 delivery system to improve Shark Slough surface water management.

Waller, B. G. 1981. Water-quality data for selected stations in the East Everglades, Florida. U.S. Geological Survey, Open File Rep. 81-821. (56)

Results of water-quality samples from three canal stations, four marsh stations and two ground-water stations within the East Everglades. Parameters analyzed include macronutrients, major ions, and trace elements. Bottom material was sampled twice for macronutrients, trace elements, and chlorinated-hydrocarbon insecticides.

Waller, B. G., and Earle, J. E. 1975. Chemical and biological quality of water in a part of the Everglades, southeastern Florida. U.S. Geological Survey, Water Resources Investigations 56-75. (57)

A comprehensive monitoring network was established in a part of the Everglades to evaluate the quality of water being delivered to Everglades National Park. Physical, chemical, and biological parameters were determined in surface water, bottom sediment, and bulk precipitation (rainfall and dry fallout).

(Other references relating, in part, to water quality include 7, 10, 68, 109, 146, 152, 154, 158, 159, 160).

IV. FISH

A. Rock-mining

Clugston, J. P. 1963. Growth of the Florida largemouth bass, *Micropterus salmoides floridanus* (LeSeru), and the northern largemouth bass, *M. s. salmoides* (Lacipede), in subtropical Florida. Trans. *Am. Fish. Soc.* 93:146-154. (58)

Study ponds (borrow pits) were stocked with both subspecies of largemouth bass. Both subspecies grew very fast, but the northern did not mature at 9 months of age as did the Florida largemouth bass.

Dineen, J. W. 1965. Special report, Tigertail Rockpit. Federal Aid in Fish Restoration Project F-16-R. Florida Game and Fresh Water Fish Commission, West Palm Beach, Fla. (59)

A redear sunfish, largemouth bass population was successfully established after rotenone treatment of a stunted bluegill largemouth bass population. Bass growth was excellent for both [illegible] original stocking and their offspring. The redear sunfish were stunted.

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Dineen, J. W. 1966. Special report #2, Tigertail Rockpit. (60)
Federal Aid in Fish Restoration Project F-16-R. Florida Game and Fresh Water Fish Commission, West Palm Beach, Fla.

Reports on unbalanced fish populations in Tigertail rockpit. Selective bluegill poisoning and the introduction of predators (largemouth bass, snook, tarpon) failed to restore fish population balance, so the 10-acre pit was renovated and restocked.

Florida Game and Fresh Water Fish Commission. 1968. Final report: (61)
determination of effects of ditching and diking. Federal Aid in Fish Restoration Project F-16-R. Job 1E. West Palm Beach, Fla.

Marshless canals offer the poorest quality fishing, lowest pounds per acre standing crop, and lowest numbers of bass. Bass growth in the marsh is less than in a fertilized rock pit. Discussion is presented concerning the value of the marsh, extent of marsh necessary to produce good fishing, and changes in the fish population with fluctuations in water level.

Florida Game and Fresh Water Fish Commission. 1975. Pages 66-71 in (62)
Annual report Everglades Region. Tigertail Fish Management Area. West Palm Beach, Fla.

Tigertail fish management area, a 10-acre rockpit, showed signs of an unbalanced fish population in 1974 and 1975. The pit was then renovated and restocked. Factors contributing to the unbalanced population are discussed. Continued fish population monitoring and an aquatic plant control program are recommended.

Florida Game and Fresh Water Fish Commission. 1977. Utilization (63)
of private excavation ponds and lakes for public fishing. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Ownership and possibility for public fishing were determined for 125 ponds and lakes. Nineteen ponds were opened for public fishing. Eleven ponds were surveyed to determine appropriate fish management procedures, physical characteristics. Results and recommendations are summarized.

Florida Game and Fresh Water Fish Commission. 1978. Snook (64)
introduction - stocking and monitoring. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Snook were stocked in three lakes (excavation pits). Catch per unit effort, species diversity, and size distribution of all fish were determined by electrofishing, gill netting, and rotenone sampling.

Florida Game and Fresh Water Fish Commission. 1978. Public lake (65)
and stream survey and management - technical services for public waters. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Seven public ponds (excavation pits) were inspected and approved for stocking. Stocking rates were 500 bluegill and/or redear sunfish per acre and 100 largemouth bass per acre. A fertilization program was implemented on one lake to stimulate food chain production. (66)

Florida Game and Fresh Water Fish Commission. 1978. Technical services for private waters. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Newly excavated ponds were inspected and stocked. Stocking rates were 500 bluegill and/or redear sunfish per acre and 100 largemouth bass per acre.

Florida Game and Fresh Water Fish Commission. 1979. Snook introduction. Fish management annual progress report: Everglades Region. West Palm Beach, Fla. (67)

Fisheries data from three research ponds (excavation lakes) were collected. Species composition, size distribution and abundance were determined from electrofishing, gillnetting, and rotenone samples.

Florida Game and Fresh Water Fish Commission. 1980. Environmental impact services. Fish management annual progress report: Everglades Region. West Palm Beach, Fla. (68)

A summary of 106 fish kills; includes numerous citations of fish kills on excavation pits caused by low dissolved oxygen or low water temperatures.

Florida Game and Fresh Water Fish Commission. 1980. Snook introduction, stocking and monitoring. Fish management annual progress report: Everglades Region. West Palm Beach, Fla. (69)

Fish lakes (excavation lakes) were sampled after the introduction of snook. Species composition, size distribution, relative abundance, and standing crop estimates of all fish are given.

Hogg, R. G. 1976. Established exotic Cichlid fishes in Dade County, Florida. Fla. Sci. 39(2):96-103. (70)

The expansion of the range of 8 species of exotic cichlid fishes in Dade County, Florida is presented. The establishment of the spotted tilapia in a quarry lake is noted. Possible sources of the introduction of the exotics is suggested.

Kushlan, J. A., and T. E. Lodge. 1974. Ecological and distributional notes on the freshwater fish of southern Florida. Fla. Sci. 37(2):110-128. (71)

The distribution and habitat of the 108 species of freshwater fish fauna in southern Florida are described. Included are several references to fish using borrow pits.

Levine, D. S., J. T. Krummrich, and P. L. Shafland. 1979. Renovation of a borrow pit in Levy County, Florida containing Jack Dempseys (Cichlasoma octofasciatum). Contribution 21 non-native fish research laboratory, Boca Raton, Fla. (72)

A small borrow pit was renovated with rotenone to remove the exotic fish, Jack Dempsey. Nineteen species of fish were recovered, five species were documented as reproducing (brown bullhead, golden shiners, bluegill, warmouth, and Jack Dempsey). Stomach contents from Jack Dempseys were primarily ostracods and chironomids.

Despite the steep sloped shoreline of the pit, 50% of the edge was vegetated with Bacopa, Chara, and Typha.

Shafland, P. L. 1976. The continuing problem of non-native fishes in Florida. Fisheries 1(6):25. (73)

The number of reproducing populations of non-native fishes in Florida has increased to 25 species and five hybrids. In a small borrow pit south of Miami, only 1.7% of the standing crop was native fishes. The rest was comprised of 8 exotic species, primarily Tilapia mariae and T. zilli.

(Other references relating, in part, to fish in rock-mining areas include 16, 28).

B. General, South Florida

Bangham, R. V. 1940. Parasites of freshwater fish of southern Florida. Fla. Acad. Sci. 5:289-307. (74)

A total of 1,380 fish belonging to sixteen families and 45 species of freshwater fish were examined.

Carlson, J. E., and M. J. Duever. 1977. Seasonal fish population fluctuations in south Florida swamp. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 31:603-611. (75)

Monitored fish populations in a southwest Florida cypress strand system. Population densities ranged from 0-8 fish/m². Wet season populations were probably controlled by hydrologic factors, but predation was important in determining dry season density, biomass, and species composition.

Clugston, J. P. 1966. Centrarchid spawning in the Florida Everglades. Q. J. Fla. Acad. Sci. 29(2):137-143. (76)

Centrarchid spawning behavior, characteristics, and habitat requirements are presented. Data on time of the year, peak spawning period, temperature, and nest locations were collected on largemouth bass, bluegill, redear sunfish, and spotted sunfish. The relationship of spawning characteristics to fish management strategies is discussed.

Courtney, W. R., H. F. Sahlman, W. W. Miley, and D. J. Herrema. 1974. Exotic fishes in fresh and brackish waters of Florida. Biol. Conserv. 6(4):292. (77)

Identifies 38 species and several hybrids of exotic fishes in fresh and brackish waters of Florida. Twenty species and five hybrids are at present established in the form of reproducing populations. The ornamental aquarium fish industry has been the major source of these introductions. Several methods of introduction are considered, and recommendations are made for preventing repetitions in the future. Future dispersal of exotics by channelization projects should become part of environmental impact statements.

Crowder, J. P. 1974. The freshwater fishes and fisheries of south Florida. U.S. Bur. Sport Fish. Wildl. PB-231-631. (78)

Native species of fishes of Florida and adjacent waters are listed by family, common name, and scientific name. References of inventories, samples, and measurements of fish populations in south Florida are given.

Dineen, J. W. 1964. Fish population study of five Everglades canals. Federal Aid in Fish Restoration Project F-16-R. Job 1-B. Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Fla. (79)

Canals with no adjacent marsh or only a temporary marsh had a standing crop of fish of 84-290 lb/acre, while canals with adjacent marsh had 450-1,88 lb of fish/acre. By weight, fish composition ranged from 1% to 22% for bass, 33%-78% bream, 8%-60% gar and bowfin. On recently renovated canals, one-year-old bass averaged in length 9.7-11.9 inches while two-year-olds averaged 15-16.8 inches.

Dineen, J. W. 1965. Fish population study of the Florida Everglades. Federal Aid in Fish Restoration Project F-16-R. Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Fla. (80)

The fish species, relative abundance, habitat preference, and fish ecology in the Everglades are examined. In 1961-62 the standing crop of fish in the Everglades marsh averaged 42.9 lb/acre with a range of 3.7-155.7 lb/acre. In 1963-64 standing crop averaged 39.9 lb/acre with a range of 15.8-91.4 lb/acre. Chubsucker, bowfin, bass, gar, warmouth, and shellcracker were the major fishes by weight.

Dineen, J. W. 1974. The fishes of the fresh water Everglades. Environments of south Florida: present and past. Memoir 2: Miami Geological Society, Miami, Fla. (81)

Forty-three species of fishes representing 18 families were collected from the Everglades during a 12-year time span covering two fish population sampling programs. A brief description of the distribution and relative abundance of these fishes is presented, along with notes concerning habits, habitat preferences, rare fishes, exotic fishes, and newcomers to the Everglades fish fauna.

Florida Game and Fresh Water Fish Commission. 1980. Non-native (82)
fish investigation. Fish management annual progress report: Everglades Region. West Palm Beach, Fla.

Species composition, size distribution, relative abundance, and standing crop estimates of fish in canal systems in south Florida.

Herke, W. H. 1959. Comparison of the length-weight relationship (83)
of several species of fish from two different, but connected, habitats. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 3:289-312.

Examines the condition factor of largemouth bass, bluegill, and redear sunfish in a south Florida lake and an adjacent marsh canal. Bass from the canal were significantly heavier for any given length than lake bass. The author feels that the crowded fish conditions in the canal facilitated bass feeding and subsequent growth.

Houde, E. D. 1971. Survey of the literature relating to sport and (84)
commercial fishes in south Florida. U.S. Natl. Mar. Fish. Serv. PB-231 669. II.

An annotated bibliography on literature relating to fish and fisheries in south Florida. It covers the period of 1960-71.

Kautz, R. S. 1980. Effects of eutrophication on the fish (85)
communities of Florida lakes. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 34:67-80.

Analysis of the trophic status and fish populations of 22 Florida lakes. Fish biomass and density is lowest in oligotrophic lakes. Sport fishes reach maximum biomass and optimum densities in mesotrophic-eutrophic lakes with a total nitrogen concentration of 1.2 mg/l and a chlorophyll *a* concentration of 11.0 mg/l.

Kushlan, J. A. 1974. Quantitative sampling of fish populations in (86)
shallow, freshwater environments. Trans. Am. Fish. Soc. 103:348-352.

The various methods and bias in sampling fish populations in the shallow, freshwater marshes of southern Florida. The most precise data was obtained by bottomless drop traps which are moved to new sites for each sample.

Kushlan, J. A. 1976. Environmental stability and fish community (87)
diversity. Ecology 57(4):821-825.

During a unique 27-month period of water level stability in the Everglades, fish density decreased, but biomass, average size of fish, species richness, and species diversity increased. Large carnivorous fish, which are poorly adapted to fluctuating marshes, became dominant during this period of stability. The fish community of the Everglades marshes oscillates between opposing tendencies of species dominance, which depend on the degree of water stability.

Kushlan, J. A. 1980. Population fluctuations of Everglades fishes. Copeia 1980(4):870-874. (88)

Effect of water level changes on population levels of fishes on both a seasonal and long-term basis.

Wegener, W., and D. Holcomb. 1972. An economic evaluation of the 1970 fishery in Lake Tohopekaliga, Florida. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:628-634. (89)

Demonstrates the importance and approximate monetary value of littoral and limnetic segments of Lake Tohopekaliga. Based on fish values published by the Florida Department of Air and Water Pollution Control, littoral areas of the lake were worth $1,333 per acre and limnetic areas $321 per acre.

Wegener, W., D. Holcomb, and V. Williams. 1973. Sampling shallow water fish populations using the Wegener ring. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 27:663-673. (90)

The design, cost, practical application, and a case study using the Wegener Ring.

(Other references relating, in part, to fish include 7, 19, 21, 46, 49, 85, 96, 159, 160).

V. Wildlife

A. General, South Florida

Crowder, J. P. 1974. The exotic vertebrates of south Florida. U.S. Bur. Sport Fish. Wildl. PB-231 241. (91)

Species of introduced exotic vertebrates of south Florida are identified and described. The principal factors responsible for their introductions are explored and recommendations are made for alleviation of current problems caused by exotics and for prevention of further harmful introductions.

Crowder, J. P. 1974. Native reptiles and amphibians of south Florida. U.S. Bur. Sport Fish. Wildl. PB-231 632. (92)

Distributions of 74 species of reptiles and amphibians of south Florida are listed. Destruction of habitat is identified as the predominant factor in the decline of the regions' reptile and amphibian species.

Harlow, R. F., and F. K. Jones. 1965. The white-tailed deer in Florida. Fla. Game Fresh Water Fish Comm. Tech. Bull. 9. (93)

A detailed review of the many investigations conducted in Florida concerning white-tailed deer and the effect these studies have had on the formulation of herd management policy.

Kahl, M. P. 1964. Food ecology of the wood stork (*Mycteria americana*) in Florida. Ecol. Monogr. 34:97-117. (94)

Kushlan, J. A. 1974. Observations on the role of the American alligator (*Alligator mississippiensis*) in the southern Florida wetlands. Copeia 4:943-946. (95)

The digging and maintaining of ponds by alligators provides a valuable refuge for aquatic organisms during south Florida's dry season. Fish numbers and species were greatest in the ponds during the dry season. Present water management has altered this relationship as canals currently provide refuge in many areas.

Kushlan, J. A. 1976. Wading bird predation in a seasonally fluctuating pond. Auk 93:464-476. (96)

Bird predation removed 76% of the fish biomass.

Loveless, C. M. 1959. The Everglades deer herd life history and management. Fla. Game Fresh Water Fish Comm. Tech. Bull. 6. (97)

Detailed study of the ecology of the Everglades deer.

Ogden, J. C. 1978. Status and nesting biology of the American crocodile, *Crocodylus acutus* (Reptilia, Crocodilidae), in Florida. J. Herpetol. 12(2):183-196. (98)

Rodgers, D. P. 1974. Waterfowl in south Florida. U.S. Bur. Sport Fish. Wildl. PB-231 655. (99)

Waterfowl kill and survey data for south Florida is summarized. The long term trend is a reduction in numbers of most species, which is largely attributable to the general decline in North American waterfowl habitat in central and northern Florida and northern states.

Rodgers, D. P., and J. P. Crowder. 1974. Threatened and endangered wildlife of south Florida. U.S. Bur. Sport Fish. Wildl. PB-231 654. (100)

The 34 endangered or otherwise threatened wildlife species of south Florida are identified and described. Problems peculiar to each species are considered in detail. Recommendations are made for the protection and enhancement of surviving populations.

Schemnitz, S. D. 1972. Populations of bear, panther, alligator, and deer in the Florida Everglades. U.S. Bur. Sport Fish. Wildl. PB-231 620. (101)

The population status of the Florida black bear, white-tailed deer, American alligator, and Florida panther was studied by various methods. Black bear and panther population estimates were 145 and 92, respectively, while the deer herd was estimated at 20,000. Alligator populations have increased despite the loss of more than 1.5 million acres of habitat.

Smith, A. T. 1980. An environmental study of Everglades mink (*Mustela vision*). South Florida Research Center Report T555. Everglades National Park, Homestead, Fla. (102)

Analysis of observations, live trapping, sign, scats, diet, and carcasses.

(Other references relating, in part, to wildlife include 7, 16, 28, 44, 118, 158, 159, 160).

VI. Macroinvertebrates

A. General, South Florida

Beck, E. C., and W. M. Beck. 1959. A checklist of the Chironomidae (Insecta) of Florida (Diptera: Chironomidae). Bull. Fla. State Mus. 4(1):86-96. (103)

Annotated list of described species of chironomids, including geographic and annual distributions.

Beck, W. M., and E. C. Beck. 1966. Chironomidae (Diptera) of Florida: I. Pentaneurini (Tanypodinae). Bull. Fla. State Mus. 19(8):305-379. (104)

Based on wild and reared specimens, larvae, pupae, and adults are described and diagnostic characteristics defined; some ecological data.

Dineen, J. W. 1964. Bottom study of the Florida Everglades and associated canals. Federal Aid in Fish Restoration Project F-16-R. Job 1-B. Florida Game and Fresh Water Fish Commission, Fort Lauderdale, Fla. (105)

New and old canals were similar in the number of organisms per square foot. Canals averaged 20-28 organisms/ft^2 while marsh communities averaged 28-182 organisms/ft^2. The average displacement volume of these organisms was 0.16-3.10 ml for canals and 2.78-3.01 ml for marsh communities. Organisms found in canals and the marsh in decreasing order of abundance were: Chironomidae, Ealitradae, Balaemonidae, Caenidae, Sphaerlidae, and Culcidae.

Kushlan, J. A. 1975. Population changes of the apple snail, *Pomacea paludosa*, in the southern Everglades. Nautilus 89:2123. (106)

Data from a six-year sampling program provided information on apple snail populations under conditions of fluctuating water levels and continuously high water levels. Higher population levels were obtained under more permanent water conditions.

Kushlan, J. A., and M. S. Kushlan. 1980. Population fluctuations of the prawn, *Palaemonetes paludosus*, in the Everglades. Am. Midl. Nat. 103(2):401-403. (107)

Population levels and ecologic role of the prawn are influenced by hydrologic conditions. Population levels were high in years when water levels fluctuated in a typical seasonal pattern, but decreased by about half when the typical dry season did not occur.

Kushlan, J. A., and M. S. Kushlan. 1979. Observations on crayfish in the Everglades, Florida, U.S.A. Crustaceana, Suppl. 5:116-120. (108)

Population responses to seasonal and annual variation in the hydrologic regime. Standing crop varied by location depending in part on water depth.

Waller, B. G. 1976. Analysis of selected benthic communities in the Florida Everglades with reference to their physical and chemical environment. U.S. Geological Survey Water-Resources Investigations 76-28. (109)

Investigation determined species diversity and numbers of benthic macroinvertebrates in canals and marshes of the Everglades. Species diversity at all sites was generally in a range indicative of degraded water quality. The number of organisms per square meter of bottom surface ranged from 43 to 8,200. Physical factors such as depth, velocity, substrate, and water fluctuation were responsible for low species diversities and the variable numbers of organisms. Water quality analysis indicated no gross contamination from sewage or agricultural runoff.

Wegener, W. D., V. Williams, and T. D. McCall. 1974. Aquatic macroinvertebrate responses to an extreme drawdown. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 28:126-144. (110)

An extreme drawdown conducted on Lake Tohopekaliga, Florida, improved littoral substrate, stimulated development of aquatic macrophytes and increased invertebrate standing crop.

(Other references relating, in part, to macroinvertebrates include 72, 74, 152, 159, 160).

VII. Vegetation

A. Rock-mining

Beny, C. R. 1979. Reforestation of borrow pits by use of specific mycorrhizal fungi, soil amendments and site preparation. Dep. (111)

of Energy, Southeastern Forest Experiment Station Annual Progress Report, Athens, Ga.

Third year results are presented from three separate studies concerned with reclamation of borrow pits using specific mycorrhizal fungi and various soil amendments.

Brandt, C. J., and R. W. Rhoades. 1972. Effects of limestone dust accumulation on composition of a forest community. Environ. Pollut. 3:217-225. (112)

Brandt, C. J., and R. W. Rhoades. 1973. Effects of limestone dust accumulation on lateral growth of forest trees. Environ. Pollut. 4:207-213. (113)

Darley, E. F. 1966. Studies on the effect of cement-kiln dust on vegetation. J. Air Pollut. Control Assoc. 16(3):145-150. (114)

Florida Rock and Sand Company, Inc. 1981. Habitat evaluation for permit application No. 79P-0117. Unpublished report to U.S. Army Corps of Engineers, Jacksonville, Fla. (115)

Detailed quantitative wetland evaluation on a rockmining area utilizing HEP (habitat evaluation procedure), which provides methodology to quantify habitat values.

Manning, W. J. 1971. Effects of limestone dust on leaf condition, foliar disease incidence, and leaf surface microflora of native plants. Environ. Pollut. 2:69-76. (116)

(Other references relating, in part, to vegetation in rock-mining areas include 12, 16, 22, 25, 31, 72).

B. General, South Florida

Craighead, F. S. 1971. The trees of south Florida, the natural environments and their succession. Univ. of Miami Press, Coral Gables, Fla. (117)

Crowder, J. P. 1974. Exotic pest plants of south Florida. U.S. Bur. Sport Fish. Wildl. PB-231 619. (118)

Existing literature, personal experience, observation, and consultation with experts were used to examine the origins, modes of introduction, growth habits, and ecological impacts of seven species of naturalized exotic pest plants of south Florida; (*Melaleuca quinquenervia*, *Schinus terebinthfolius*, *Casuarina glauca*, *Causarina equisetifolia*, *Eichhornia crassipes*, *Hydrilla verticillata*, *Alternanthera philoxeroides*). The adaptability of *Melaleuca* to a wide range of soil and moisture conditions and its tendency to reproduce in response to stress (fire, mechanical damage) apparently encourage it to spread at the expense of native plants, in many instances displacing indigenous vegetation of value to wildlife. *Schinus* and the *Casuarina* likewise displace native vegetation without providing significant wildlife habitat.

Davis, J. H., Jr. 1943. The natural features of southern Florida, especially the vegetation and the Everglades. Fla. Geol. Surv. Bull. 25. (119)

Davis, J. H. 1967. General map of natural vegetation of Florida. Agricultural Experiment Stations Institute of Food and Agricultural Sciences, Circular S-178, Univ. of Florida, Gainesville. (120)

Kadlec, J. A., and W. A. Wentz. 1974. State-of-the-art-survey and evaluation of marsh plant establishment techniques: induced and natural. Volume 1: Report of research. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. (121)

Ledin, R. B. 1951. The Compositae of south Florida. Fla. Acad. Sci. 14(2):51-207. (122)

Description of the species of composites along with a key based on vegetative characteristics.

Loope, L. L. 1980. A bibliography of south Florida botany. South Florida Research Center Report T-600. Everglades National Park, Homestead, Fla. (123)

Selected bibliography relating to south Florida botany.

Loveless, C. M. 1959. A study of the vegetation in the Florida Everglades. Ecology 40(1):1-9. (124)

The vegetation characterizations of the sawgrass, wet prairie, slough, and tree island communities are given. The role of fire is analyzed as a factor influencing the flora composition.

Lowe, S. B. 1979. Trees and shrubs for the improvement and rehabilitation of pits and quarries in Ontario. Ministry of Natural Resources, Toronto, Ontario. (125)

Industry background, site planning, preparation, design, maintenance, species selection. Description of recommended trees and shrubs, sources for purchase.

Myers, R. L. 1975. The relationship of site conditions to invading capability of *Melaleuca quinquenervia* in southwest Florida. M.S. Thesis. Univ. of Florida, Gainesville. (126)

Ability to invade disturbed and undisturbed wetland sites in southwest Florida. Includes range, distribution, uses and conditions needed for establishment.

Olmstead, I. D., L. L. Loope, and C. E. Hilsenbeck. 1980. Tropical hardwood hammocks of the interior of Everglades National Preserve. South Florida Research Center, Report T-604, Everglades National Park, Homestead, Fla. (127)

Riopelle, L. A. 1978. Melaleuca control at Corkscrew Swamp Sanctuary Ecosystem Research Unit, National Audubon Society, Naples, Fla. (128)

Methods and techniques used for eradicating melaleuca infestations.

Sheiph, K. H., M. A. Ozturk, O. Secmen, and Y. Vardar. 1976. Field studies of the effects of cement dust on the growth and yield of olive trees in Turkey. Environ. Conserv. 3(2):117-121. (129)

Six species of herbaceous plants were found in areas polluted by cement kiln dust while 26 species were found in nonpolluted areas. There was up to a 55% reduction in growth and fruit yield on olive trees in polluted areas.

Steward, K. K., and W. H. Ornes. 1975. The autecology of sawgrass in the Florida Everglades. Ecology 57:162-171. (130)

Characterizes sawgrass stands by standing crop, plant density, stem length, leaf numbers, and growth rate. Both mature sawgrass stands as well as stands regrowing after fires were examined. Nutrient level relationships in plant tissue, soil, and water were investigated.

Wentz, W. A., R. L. Smith, and J. A. Kadlec. 1974. State-of-art survey and evaluation of marsh plant establishment techniques: induced and natural. Volume II: A selected annotated bibliography on aquatic and marsh plants and their management. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. (131)

(Other references relating, in part, to vegetation include 17, 44, 158, 159, 160).

VIII. Aquatic Macrophytes, Plankton

A. Rock-mining

Florida Game and Fresh Water Fish Commission. 1978. Transplant and monitor aquatic vegetation. Fish management annual progress report: Everglades Region. West Palm Beach, Fla. (132)

Desirable aquatic plants were transplanted into excavation lakes in an attempt to improve sportfish production and wildlife utilization. Transplant success varied by species and ranged from 0 to 100% transplant success.

Florida Game and Fresh Water Fish Commission. 1979. Transplant and monitor aquatic vegetation. Fish management annual progress report: Everglades Region. West Palm Beach, Fla. (133)

Aquatic plant species, arrowhead, pickerel weed, white waterlily, and spatterdock were successfully transplanted into two excavation lakes containing a low density and diversity of aquatic plants. Percent survival and growth are given.

Florida Game and Fresh Water Fish Commission. 1980. Aquatic plant introduction. Fish management annual progress report: Everglades Region. West Palm Beach, Fla. (134)

Growth and expansion of arrowhead, spatterdock, pickerel weed, and white waterlily were monitored after transplanting into two excavation pits.

Florida Game and Fresh Water Fish Commission. 1980. Annual report 1979-80 Everglades Region. Tigertail Fish Management Area. Pages 1-22-1-24. West Palm Beach, Fla. (135)

Bioassays were conducted to determine the limiting factor in plankton production in Tigertail Rockpit. Manganese appeared to be limiting and it is recommended that it should be introduced to the 10-acre rockpit to stimulate production.

Folit, R., N. Sipe, and M. Snow. 1975. Artificial lakes in Sarasota County, Florida, with emphasis on aquatic plant growth. New College, Environmental Studies Program, Sarasota, Fla. (136)

Survey data on 108 representative artificial lakes including age, shoreline development, function, land practices, and many morphometric parameters. Includes recommendations for limiting aquatic plant growth.

Pope, R. L. 1967. A qualitative and quantitative study of the plankton communities in two limestone quarry lakes, Dade County, Florida. M.S. Thesis. Univ. of Miami, Miami, Fla. (137)

Plankton samples were taken bimonthly for one year. The seasonal occurrence and density of phytoplankton and zooplankton genera is listed. Similarities and differences between the two quarry lakes were compared to the physico-chemical conditions. Water quality parameters taken were temperature, pH, oxygen, alkalinity, turbidity, and CO_2.

Rhoads, P. B. 1979. A study of the phytoplankton primary production and plankton ecology of a shallow, artificial lake, Miami, Florida. M.S. Thesis. Univ. of Miami, Miami, Fla. (138)

The relationship of the plankton community to the ecology of a residential quarry lake was evaluated. Phytoplankton primary production was correlated with physicochemical parameters and plankton fluctuations.

White, P. F. 1964. Growth conditions of some macrophytic aquatic communities in some southern Florida canals. M.S. Thesis. Univ. of Florida, Gainesville. (139)

Standing crop of plants was determined for four canals and a borrow pit. Factors influencing plant growth were (1) amount of light at different depths and seasons and (2) nitrogen content of the waters.

Wood, E. J., and N. G. Maynard. 1974. Ecology of the microalgae of the Florida Everglades. Environments of south Florida: present and past. Pages 123-145 *in* P. J. Gleason, ed. Memoir 2: Miami Geological Society, Miami, Fla. (140)

The relationship between the composition of the micro-algal community and water level, salinity, and macrophyte population at selected Everglades communities is examined. Phytoplankton, periphyton, and benthos community structures are listed. Low diversity was noted for a borrow pit community.

(Other references relating, in part, to aquatic macrophytes or plankton in rockmining areas include 24, 25, 28, 31, 32, 72).

B. General, South Florida

Brock, T. D. 1970. Photosynthesis by algal epiphytes of *Utricula* in Everglades National Park. Bull. Mar. Sci. 20:952-956. (141)

Studies on photosynthesis in macrophytes and associated algal epiphytes. The author suggests that the epiphytes rather than the macrophytes are responsible for the bulk of primary production in this aquatic ecosystem.

Browder, J. A. 1981. Perspective on the ecological causes and effects of the variable algae composition of southern Everglades periphyton. South Florida Research Center Report T-643. Everglades National Park, Homestead, Fla. (142)

Taxonomic composition, factors affecting composition, and ramifications of compositional variation on aquatic animals that feed on periphyton.

McPherson, B. F. 1973. Vegetation in relation to water depth in conservation area 3, Florida. U.S. Geological Survey, Open File Rep. 73025. (143)

Biomass of slough vegetation generally decreased with lower water level both at a given station and between stations; it ranged from 16,340 g/m² at a water depth of 0.8 m to less than 200 g/m² at 0.1 m.

Taylor, W. D., F. A. Hiatt, S. C. Hern, J. W. Hilgert, V. W. Lambou, F. A. Morris, M. K. Morris, and L. R. Williams. 1978. Distribution of phytoplankton in Florida lakes. U.S. (144)

Environmental Protection Agency, Las Vegas, Nev. EPA-600/3-78-085. (145)

Species and abundance of phytoplankton in the 40 lakes sampled by the National Eutrophication Survey in the State of Florida. Includes species diversity, abundance indices, Nygaard's trophic state index, and Palmer's organic pollution index.

Van Meter, N. N. 1965. Some quantitative and qualitative aspects of periphyton in the Everglades. M.S. Thesis. Univ. of Miami, Miami, Fla.

Includes a listing of the 167 genera of periphyton found during the study. An annual, seasonal, logarithmic increase in total periphyton biomass was dependent on water level. The relative importance, ecology, and distribution of periphyton in several Everglades communities is presented.

(Other references relating, in part, to aquatic macrophytes or plankton include 35, 46, 73, 131, 159, 160).

IX. Heavy Metals, Pesticides

A. General, South Florida

Freiberger, H. J., and B. F. McPherson. 1972. Water quality at Miami International Airport, Miami, Florida, 1971-72. U.S. Geological Survey, Open File Rep. 72023. (146)

Quality of water, sediment, and biota was determined at canal and drainage ditches. Nitrogen, phosphorus, and pesticides were in higher concentrations than typical for undisturbed areas of south Florida, but were in the ranges reported for urban coastal areas.

Higer, A. L., and M. C. Kolipinski. 1970. Sources of pesticides in Florida waters. U.S. Geological Survey, Open File Rep. 70005. (147)

Information on pesticide use, designed to help monitor and trace pesticides in the hydrobiologic system of Florida.

Joyner, B. F. 1973. Nitrogen, phosphorus, and trace elements in Florida surface waters, 1970-71. U.S. Geological Survey, Open File Rep. 73028. (148)

Kolipinski, M. L., A. L. Higer, and M. L. Yates. 1971. Organochlorine insecticide residues in Everglades National Park and Loxahatchee National Wildlife Refuge, Florida. Pestic. Monit. J. 5(3):281-287. (149)

Mattraw, H. C. 1975. Occurrence of chlorinated hydrocarbon insecticides, southern Florida, 1968-72. Pestic. Monit. J. 9(2):106-115. (150)

Miller, W. L. 1978. Effects of bottom sediments on infiltration from the Miami and tributary canals to the Biscayne aquifer, Dade County, Florida. U.S. Geological Survey. Water-Resources Investigations 78-36. (151)

Infiltration was an important source of recharge. Bottom sediments impeded infiltration, reducing coliform bacteria, pesticides, PCB, metals and other suspended materials in infiltrating canal water.

Russo, T. N. 1974. Indicators of organic contamination in Plantation canal, Broward County, Florida 1971-72, Report of investigations No. 70, Florida Dep. of Natural Resources, Bureau of Geology. (152)

Effluent from sewage treatment plants was the principal source of organic material. Dissolved oxygen values were low, BOD high. High levels of nutrients, metals, and pesticides were found in the bottom sediments. Benthic organisms were composed of a few genera represented by large numbers of organisms.

Spitzer, P. R., R. Milton, C. Kolipinski, and A. L. Higer. 1969. Pesticides in Florida, an annotated selected bibliography, January 1965-April 1968. U.S. Geological Survey, Open File Rep. FL-69264. (153)

Waller, B. G., W. L. Miller, and T. R. Beaven. 1975. Water-quality data for canals in eastern Broward County, Florida 1969-1974. U.S. Geological Survey, Open File Rep. FL-75009. (154)

Selected water quality data including pesticide analysis of bottom sediments in primary canals of Broward County.

(Other references relating, in part, to heavy metals or pesticides include 16, 23, 26, 29, 30, 41, 42, 54, 57, 159, 160).

X. Bibliographies, Summary Reports

Duever, M. J., J. E. Carlson, J. F. Meeder, L. C. Duever, L. H. Gunderson, L. A. Riopelle, T. R. Alexander, R. F. Myers, and D. P. Spangler. 1979. Resource inventory and analysis of Big Cypress National Preserve. Vol. I and II. Final report to the U.S.D.A. National Park Service, Southeast Regional Office, Contract CX500080899. (155)

A resource inventory and analysis designed to bring together everything known about the Big Cypress National Preserve and how the information relates to management of the preserve.

Gleason, P. S., ed. 1974. Environments of south Florida: present and past. Memoir 2: Miami Geological Society, Miami, Fla. (156)

This memoir has 29 sections about the environments and ecological aspects of south Florida and the Everglades. The memoir includes sections on mammals, fishes, avifauna, periphyton, and vegetation in addition to sections on hydrology, geology, and historical development of the area.

McPherson, B. F., G. Y. Hendrix, H. Klein, and H. M. Tyers. 1976. The environment of south Florida, a summary report. Geol. Surv. Prof. Pap. 1011. U.S. Government Printing Office, Washington, D.C. (157)

Summary report of the South Florida Environmental Study. It includes an annotated bibliography of the 51 reports that comprised the study. Includes the history of the south Florida Environmental Study and summarizes the findings on freshwater, terrestrial, coastal, and man-dominated ecosystems.

Swayze, L. J. 1981. Annotated selected references on natural resources investigations, Collier County, Florida. U.S. Geological Survey, Open File Rep. 81-1184. (158)

Annotations and references for selected reports in Collier County, Fla., between 1950-1978. Biological, ecological, geological, geochemical, and hydrological headings.

Tabb, D. C. 1963. A summary of existing information on the freshwater brackish water and marine ecology of the Florida Everglades Region in relation to freshwater needs of Everglades National Park. Rosenstiel School of Marine and Atmospheric Sciences, Univ. of Miami, Miami, Fla. (159)

Summary report of over 400 published and unpublished sources.

Tabb, D. C., and E. S. Iverson. 1971. A survey of the literature relating to the south Florida ecosystem (with pertinent references from outside the geographic boundaries of the subject area). Rosenstiel School of Marine and Atmospheric Science, Univ. of Miami, Miami, Fla. Contract 14-10-6-990-043. U.S. Department of Interior, National Park Service. (160)

Yundt, S. E., and G. D. Booth. 1978. Bibliography: rehabilitation of pits, quarries, and other surface mined lands. Ontario Geol. Surv. Misc. Pap. MP 76. (161)

References primarily about pits and quarries in Ontario, includes relevant references from other countries on other minerals.

(Other bibliographies and detailed reports included in 16, 78, 84, 123, 131, 153).

XI. Index of Principal Authors, Agencies, and Societies with Corresponding Bibliographic Reference Numbers.

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16. Abstract (Limit: 200 words)

The study characterizes selected abiotic and biotic features of eight limestone excavation lakes in south Florida to help identify mitigation needs for future rock mining operations. Differences between surface and bottom water temperatures never exceeded 3°C in lakes less than 8 m. Maximum and minimum surface temperatures achieved in any lake were 33°C and 19°C respectively. Surface dissolved oxygen concentrations rarely fell below 5 mg/l in any lake sampled. For all lakes, mean total phosphorus ranged from 7.1-12.3 mg/m^3, total nitrogen from 260-942 mg/m^3, and chlorophyll a from 0.5-4.2 mg/m^3. No significant correlation among mean depth, age of lake, or surface area of each lake was found for any aforementioned nutrient ($P \geq 0.05$). Mean depth was positively correlated ($P \leq 0.05$) with total alkalinity and total hardness. Bottom sediments contained a low percentage of organic matter (0.34-3.70%). There were significant differences in mean number of macroinvertebrates/m^2 among lakes (range 218-2,704/m^2). For all lakes, age-1 largemouth bass lengths ranged from 143-206 mm, weights from 31-102 g, and condition factors from 0.99 to 1.20. Only 12% of all large-mouth bass collected were larger than 300 mm and less than 1% exceeded 350 mm in length. Recommendations for future mitigation techniques are provided including creation of additional littoral areas which are lacking in most limestone excavation lakes. An annotated bibliography of relevant references is also provided.

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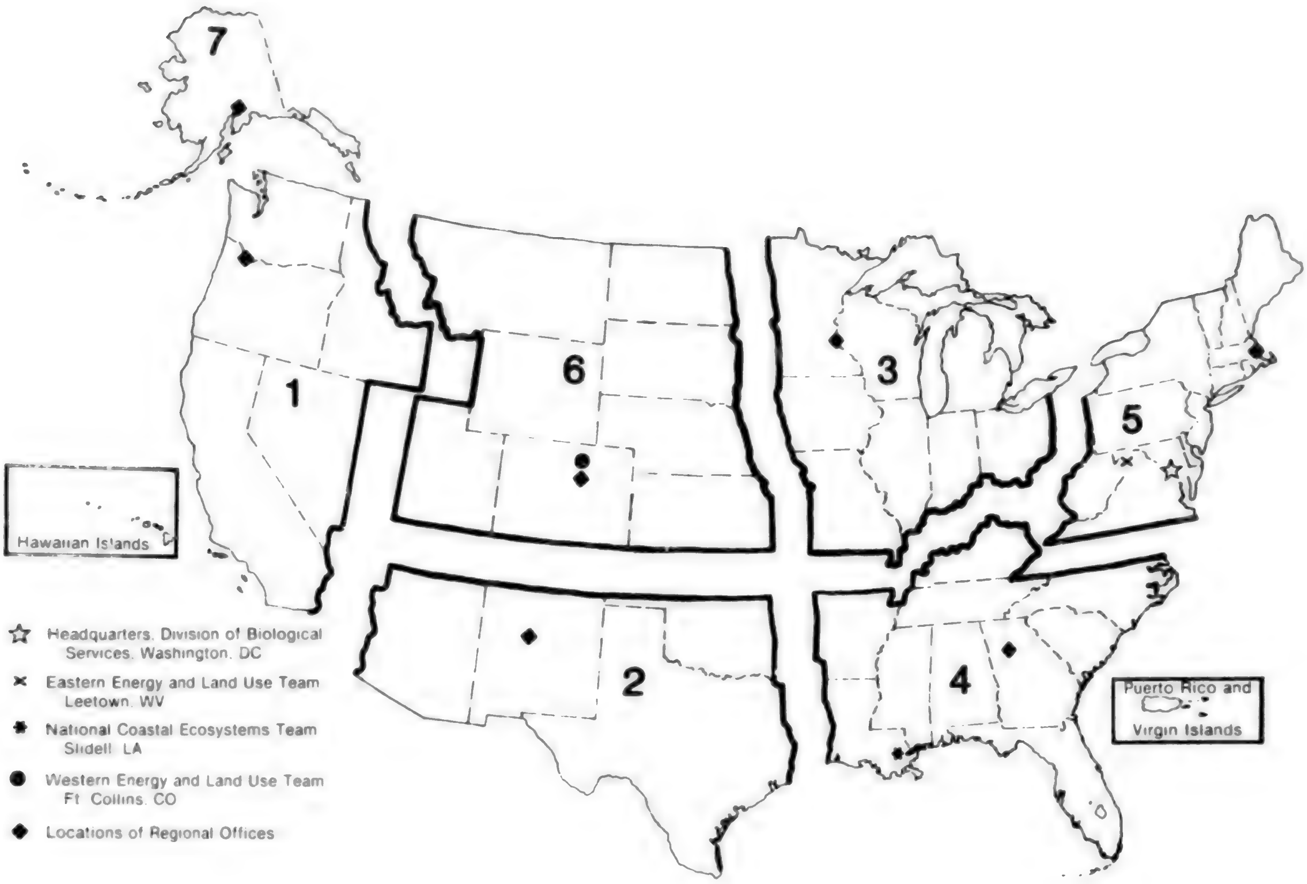
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Hawaiian Islands
Puerto Rico and Virgin Islands
☆ Headquarters, Division of Biological Services, Washington, DC
× Eastern Energy and Land Use Team Leetown, WV
✱ National Coastal Ecosystems Team Slidell, LA
● Western Energy and Land Use Team Ft. Collins, CO
◆ Locations of Regional Offices

REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

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